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FORTY-EIGHTH ANNUAL REPORT

OF THE

MASSACHUSETTS

AGRICULTURAL COLLEGE.

PART I.

REPORT OF THE PRESIDENT AND OTHER OFFICERS
FOR FISCAL YEAR ENDING NOV. 30, 1910.



BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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FORTY-EIGHTH ANNUAL REPORT

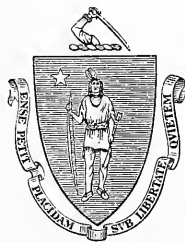
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THE STATE BOARD OF PUBLICATION.

The Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Dec. 1, 1910.

To His Excellency EBEN S. DRAPER.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part I. of the forty-eighth annual report of the trustees of the Massachusetts Agricultural College, for the fiscal year ended Nov. 30, 1910, this being the report of the president and other officers of the corporation of the college.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.



REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

I herewith submit my fifth annual report as president of the college.

ATTENDANCE.

The attendance of students of college rank for the last college year exceeded that of the previous year by 68, and aggregated 320 four-years men, 12 unclassified students of college grade and 18 graduate students; there were 260 in various short courses, making a total attendance of 610. The entering class the present autumn numbered 158, the largest previous freshman class being 131, a year ago. The total number of four-years men in present attendance is 402; of unclassified students, 17; of graduate students, 15. (See Table I.)

Eighty-five per cent. of the present freshman class come from Massachusetts, with 9 other States and 1 foreign country, China, represented.

/ About one-fifth of the class are undecided as to their intended vocation; about one-third of the whole class state that they intend to follow some phase of professional agriculture or horticulture; and considerably more than one-third of the whole class state that they intend to follow some phase of practical agriculture or horticulture. Ninety-one per cent. of those having made a decision intend to follow an agricultural vocation. Less than one-fourth of the fathers of the members of the freshman class are engaged in agriculture or horticulture, and a trifle over one-fourth of the members of the freshman class were brought up on farms, although more than one-half of those not brought up on a farm have had some farm experience. / The average age of the entering class is approximately nineteen years. (See Table IV., J.)

APPROPRIATIONS.

The total amount of special appropriations asked of the last Legislature was \$277,500; the total amount granted was \$115,625. An increase in the current annual appropriation was

asked, amounting to \$110,000; the amount granted was \$37,500. (See Table II.)

The legislative appropriation of \$15,000 has enabled us to equip in a complete manner the new building for entomology and zoölogy. Some delay was experienced in the completion of the building and the installation of the equipment; but the building is now fully used, and was dedicated with appropriate ceremonies November 11. The legislative appropriation of \$17,500 for the purchase of land has enabled the college to acquire the larger proportion of the land on which options were held.

The legislative appropriations for land made during the past three years aggregate \$23,500. This money has been expended in acquiring the following parcels:—

Appropriations for Land.

1908,	\$500 00
1909,	5,500 00
1910,	17,500 00
	<hr/>
	\$23,500 00

Expenditures for Land.

Louisa Baker property,	\$5,636 91
Old creamery property,	1,726 25
Westcott property,	2,250 00
Harlow property,	3,284 00
Kellogg property,	5,868 45
E. Baker property,	2,500 00
George Allen property,	500 00
Charmbury property,	450 00
Loomis property,	415 00
Hawley and Brown property,	675 00
	<hr/>
	\$23,305 61
Attorney's fees,	128 41
Balance,	65 98
	<hr/>
	\$23,500 00

Appropriations for two new buildings were granted by the Legislature: \$12,000 for a laboratory for pomology and market gardening, and \$10,000 for a building for animal husbandry.

The former building, while essentially an instruction building, will afford admirable facilities for both experiment and teaching in the subject of cold storage of fruits and vegetables, for packing and for other forms of laboratory work in pomology.

The animal husbandry building fills a serious gap in the college equipment, enabling the courses in stock judging to be put on a thoroughly modern basis, affording also ample room for the large classes entering during the short winter courses, serving as an auditorium for gatherings of farmers to witness demonstrations of various sorts, and, in general, as an arena for demonstration instruction. A brief description of both these buildings follows.

Building for Pomology and Market Gardening. — The new laboratory and storage building for pomology and market gardening is 74 by 42 feet, and consists of basement, one story and attic. In the basement are three large storage rooms, — one for vegetables and two for fruits, — where the bulk of the larger fruits and vegetables will be stored. On the ground floor is a large laboratory room for pomology, 18 by 56 feet, where such practicums as packing, testing spray apparatus, and other operations which require plenty of room, will be carried on. Adjoining this are three fruit rooms, — a large frost-proof room and two refrigerated rooms, one large and one small, each with its separate cooling apparatus, so that the rooms may be kept at different temperatures. In the attic are large storage rooms for fruit packages, ladders, spray pumps and the like. An elevator connects the various floors.

The vegetable gardening rooms on the main floor consist of a workroom; squash room, for storage; and four refrigerated compartments, each with its separate cooling system, to allow each being kept at a separate temperature. These rooms are designed especially for experimental work, and will be used also for the work of advanced students in vegetable gardening.

The Animal Husbandry Building. — This building, now nearing completion, is located directly south of the horse barn. It is 80 feet long and 50 feet wide, outside measurements, the longest dimension running north and south. The arena, which occupies the center of the building, is 27 by 78 feet, with tan-bark floor and large doors at each end. On the west side of this

there are five rows of seats, each row being fifteen inches above the one in front of it, so that every seat gives an unobstructed view of the arena. These seats will accommodate 180 persons without crowding. Under these there is a detention stable for stock brought from other farms; this will obviate the need of putting such stock in the college stables, and will also serve as a quarantine if needed. On the east side of the arena is a cement walk 6 feet wide, with a visitors' gallery above that will easily seat 63 people. In case of necessity chairs could be placed in one-half of the arena, giving seating capacity for 500 persons. A rolling partition across the center of the building makes it possible to use it either as one large or two smaller class rooms for judging, lectures or recitations.

The building is of brick, with slate roof, heated by steam and lighted by electricity. The cost of maintenance should be low.

COMMENCEMENT.

Commencement occurred June 22, and the college conferred the degree of Bachelor of Science on 43 men, and the degree of Master of Science on 1. The commencement address was given by Mr. Lucius Tuttle, then president of the Boston & Maine Railroad Company. President Tuttle's address was a strong discussion of the vocational trend of modern education. It was followed by remarks by Governor Eben S. Draper. The attendance at the alumni dinner was 178.

SUMMER SCHOOL.

The summer school registration for 1910 was 229. A few new courses were added, but in general the plans for our previous summer schools were duplicated.

In connection with the summer school there was held a gathering that we believe to be unique in the history of agricultural progress. Under the auspices of the summer school there was held a "Conference of Rural Social Workers" for the four days August 9 to 12 inclusive. The forenoon meetings consisted of sections, or departments, the program for each of which had been prepared by some organization representing a special interest, and included meetings for country clergymen, teachers of agriculture, rural teachers, local officers and paid workers in

the rural department of the Young Men's Christian Association, lecturers of subordinate granges, officers of village improvement societies, and rural librarians. Each afternoon all delegates were brought together for a common program on some important phase of country life. Each evening there were formal addresses. The total registration of different individuals for the four days was 335, inclusive of perhaps 40 grange lecturers, who were present only for one day.

The fundamental idea of the conference was that of bringing together for consultation about concrete methods the local leaders in the rural communities of Massachusetts. The attendance, interest and even enthusiasm of those present fully justified the meeting.

THE WINTER SCHOOL.

The attendance at the winter courses was 64, this being about the same number as enrolled in 1909. A special addition was made by the giving of a two-weeks poultry course. The school itself was concluded by a farmers' week, which furnished a most admirable program, and brought together at least 559 different people.

EXTENSION WORK.

The extension work, begun so auspiciously a year ago under the leadership of Professor William D. Hurd, has more than met expectations. In fact, so pressing have been the calls for lectures, for demonstration orchards, for correspondence courses and for other phases of work, that our faculty has been wholly unable to cope with this demand. One of the most progressive features of the last season's work was the running of a better-farming trolley train in co-operation with the State Board of Agriculture, the State forest service and the Springfield Board of Trade. The New England Securities Company, managers of some 600 miles of inter-urban trolley lines in Massachusetts, furnished the train, and made most admirable plans for the carrying out of the project. I speak of this enterprise particularly because, so far as we know, it is the first time that the inter-urban trolley has been used for agricultural educational purposes. I cannot, however, neglect to call attention to the great success of the better-farming train, run under the most

efficient management of the Boston & Albany Railroad, in which we co-operated with the State Board of Agriculture, the State grange and the State forest service.

I present here a few facts concerning the details of the work of the extension service during the past year: —

Statistics of the Extension Department.

Enrolment in conference of rural social workers,	335
Grange lecturers in above,	40
Enrolment in farmers' week,	559
Lectures given by faculty,	159
Lectures refused,	197
Total number in correspondence courses,	252
Demonstration orchards,	6
Better-farming trains: —	
Boston & Albany,	4 days
Trolley,	3 days
Attendance at lectures given from above,	9,000
Exhibits at fairs (5 or 6 lectures and demonstrations given each day at each fair),	5

Other Work of the Extension Department.

Ten-weeks course, enrolment,	64
Poultry course, enrolment,	51
Beekeepers' course, enrolment,	20
Summer school, enrolment,	229

Conference on rural progress at West Newbury.

Advisory work with Faunce Demonstration Farm at Sandwich.

Co-operative work with Smith School of Agriculture at Northampton.

Numerous visits to farms to give advice.

Hundreds of letters answered.

Co-operation with tent camp meetings.

CHANGES IN FACULTY AND OTHER OFFICERS.

Last June, Professor Charles H. Fernald resigned as director of the graduate school, professor of zoölogy and entomologist of the experiment station. He was granted a pension from the Carnegie Foundation, and was retained by the college as honorary director of the graduate school.

Professor Fernald had served the college for twenty-four years, and not only had he built up a strong department of zoölogy, but he created the department of entomology, and built

it into one of the strongest departments of its kind in the United States. It was under his leadership that the graduate work of the college had its special development, and a large number of his former pupils are occupying most important teaching positions in the field of economic entomology. The new building for entomology and zoölogy is a splendid monument to his labors, and indicates objectively something of the professional skill, teaching ability and conspicuous success of this long period of service which Professor Fernald has rendered to the Massachusetts Agricultural College.

I regret to record that soon after the beginning of this last fiscal year Dean George F. Mills was taken suddenly and seriously ill. For many weeks his condition was alarming, and it was only after a prolonged convalescence that in the late summer he was enabled to leave the house. At the opening of the college year it was quite out of the question for him to resume his duties as dean, and he was therefore granted a leave of absence for the present college year. Students and faculty alike hope that his full strength may come to him again, and that he may be long with us in the most important and delicate position which he occupies as dean.

In January, 1910, Professor Fred W. Morse accepted a temporary appointment at the experiment station as assistant research chemist; in June the trustees made this position permanent for Professor Morse. Professor Morse received his training at Worcester Polytechnic Institute, graduating from that institution in 1887, and receiving his degree of M.Sc. in 1900. From 1888 to 1909 he was employed by the New Hampshire College of Agriculture and Experiment Station; from 1896 he was vice-director of the experiment station, and from 1889 he was professor of chemistry in the college there.

During the year the trustees created the department of zoology and geology, and placed Assistant Professor Gordon in charge; previously these two subjects have been separated.

Professor Waugh was granted a leave of absence for six months, beginning February 1; he spent the period in Europe, and at the opening of the present college year was back to take up his work here. During the entire college year Professor F. C. Sears served with signal ability and marked success in Pro-

fessor Waugh's stead as acting head of the division of horticulture.

Mr. John R. Parker, graduate assistant in entomology and pomology, resigned to accept a position at the Montana College of Agriculture.

The course in rural law has been discontinued, and with it the services of Judge Robert W. Lyman of Northampton.

In February, 1910, Mr. Harold F. Thompson resigned as instructor in market gardening, and Mr. Charles S. Heller, a graduate of the Michigan Agricultural College, was elected to fill the vacancy.

Mr. Harry M. Jennison resigned his position as assistant in botany to take up work of like character in Wabash College.

Mr. Burke Hough resigned as purchasing agent, and Mr. William Chesley was appointed steward of the dining hall in his place.

During the summer Mr. Carl D. Kennedy resigned as assistant in the experiment station, and Mr. Clement L. Perkins, a graduate of the New Hampshire Agricultural College of the class of 1910, was appointed to fill the vacancy.

In June Mr. Roy F. Gaskill resigned as assistant in animal nutrition for the experiment station, and Mr. James R. Alcock is now filling that position.

Mr. Arthur I. Bourne, a graduate of Dartmouth College and formerly a graduate student at this institution, was made assistant entomologist for the experiment station in place of Mr. John N. Summers, resigned.

During the summer Miss Ola H. Perrin resigned as clerk to the director of short courses, and Miss Mabel R. Case, a graduate of Boston University, was appointed to that position.

The following minor changes in titles, etc., are also to be noted:—

In January, 1910, Dr. Joseph B. Lindsey was made vice-director of the experiment station; the title of Professor William D. Hurd was changed to that of director of extension work; Professor James A. Foord was made permanent head of the division of agriculture; Dr. James B. Paige has been acting dean since Jan. 1, 1910, in the absence of Professor Mills; Mr. Anderson A. Mackimmie was elected assistant to

the dean; Professor Henry T. Fernald, on the resignation of Professor Charles H. Fernald, was chosen entomologist for the experiment station and acting director of the graduate school; Professor Philip B. Hasbrouck resumed his duties in September, after a year's leave of absence; Assistant Professor William P. B. Lockwood was made associate professor of dairying; Assistant Professor Robert W. Neal was made associate professor of English; Mr. Sidney B. Haskell was made assistant professor of agronomy; Mr. Floyd B. Jenks was made assistant professor of agricultural education; Dr. Alexander E. Cance was made assistant professor of agricultural economics; Mr. Frederick B. McKay was made assistant professor of public speaking and English; the title of Mr. John Summers was changed to that of graduate assistant.

OFFICERS FOR NEW POSITIONS.

In 1909 the department of forestry was created; not until August, 1910, was there secured a suitable man to take charge of this work. Frank F. Moon, A.B., M.Fr., was elected as associate professor of forestry, and began his duties September 1. Professor Moon graduated from Amherst College in 1901, and from Yale Forest School in 1909; he has had experience in the United States Forest Service, and with the Fish and Game Commission of New York State.

Dr. Burton N. Gates was chosen assistant professor of beekeeping. Dr. Gates graduated from Clark College in 1905 with the degree of A.B., and in 1906 received the degree of A.M. from the same institution; he attended Cornell University and took his Ph.D. degree there in 1909. He has been serving in the United States Bureau of Entomology since 1906 as expert in apiculture, and later as assistant in apiculture. Dr. Gate's employment began July 1; he will serve as expert in beekeeping for the experiment station and as inspector of apiaries for the State Board of Agriculture, as well as assistant professor of beekeeping in the college.

Mr. Alvah J. Norman was elected as instructor in pomology, his services beginning Sept. 14, 1910. Mr. Norman graduated from the Iowa State College in 1906, and received the degree of M.Sc. from the Maryland Agricultural College in 1910; he

will devote most of his time to work in the extension and short course department.

Mr. Charles J. Robinson has recently been made instructor in dairying and animal husbandry. Mr. Robinson is a graduate of the University of Illinois of the class of 1909, and has had wide experience in practical dairy work. He will assist in the extension and short course work of the college as well as in the regular courses.

Mr. Sumner C. Brooks fills the position as assistant botanist for the experiment station created by the trustees in January, 1910. Mr. Brooks is a graduate of the Massachusetts Agricultural College of the class of 1910.

Mr. W. A. Turner is serving as assistant in chemistry. Mr. Turner graduated from the Sheffield Scientific School in 1910, with the degree of Ph.B.

The trustees authorized an assistant in the department of English, and elected Miss Helena Goessmann of Amherst to the position; Miss Goessmann's active services are to begin Jan. 1, 1911.

Mr. E. M. J. Evans is serving temporarily as laboratory assistant in bacteriology.

Miss Dorothy Mudge of Boston was appointed to the position of clerk in the office of the treasurer, created by the trustees in June, 1910.

DEATH OF DR. GOESSMANN.

On September 1, Dr. Charles A. Goessmann passed away. His connection with the college began in January, 1869, and continued uninterruptedly until 1907, when he was relieved of his active duties and made honorary director of the experiment station, and in June, 1908, honorary professor of chemistry.

I cannot here record the services nor eulogize the work of Dr. Goessmann. Appropriate memorial exercises were held in the college chapel October 12, and some steps will be taken to preserve in permanent form a record of his work. But I cannot refrain from calling your attention to the fact that it is the work and the character of men like Dr. Goessmann that, after all, make an educational institution great and strong. We need land, we need buildings, we need teaching equipment

and apparatus; but we must have superior men. A strong, virile man with inferior equipment is worth any number of inferior men with the most modern equipment. One lesson of Dr. Goessmann's life as it affects the management of our college is that of careful selection of strong investigators and teachers, and reasonable and justifiable rewards for their work.

LEGISLATIVE BUDGET.

The legislative budget, as voted by the board of trustees at its meeting in Boston, November 4, may be summarized as follows: —

*Requested Increases in Current Funds, Available for Fiscal Year,
Dec. 1, 1911, to Nov. 30, 1912.*

ITEMS.	Increase.	Total.
Administration,	\$4,250	\$25,000
Maintenance and equipment,	43,250	88,000
Investigations,	5,000	15,500
Instruction,	22,500	70,500
Short courses and extension teaching,	15,000	30,000
Inspection service,	—	3,000
	\$90,000	\$232,000

Requests for Appropriations for Special Purposes, 1911.

Improvements, west experiment station building,	\$7,500
Enlargement of Draper Hall,	25,000
Dormitory,	20,000
Dairy building and equipment,	75,000
Department equipment,	15,000
Repairs,	20,000
General improvements,	25,000
	<hr/> \$187,500

A brief statement or explanation of the need of these various amounts may well be made a part of this report.

Reclassification of Current Funds. — The trustees voted to ask the Legislature for an increase in current annual income, totaling \$90,000 a year, divided into six different heads, representing the main types of work followed by the institution, namely: administration, maintenance and equipment, investiga-

tion, instruction, short courses and extension teaching, inspection service.

An explanation of the increases asked for will be clearer if I retain the old classification at this point. The following are the items:—

Instruction. — Increase, \$15,000. This amount would bring the total for instruction purposes to \$70,500, \$5,000 more than was asked of the Legislature last year. This increase is necessary in part because of the increase in attendance of students. During the past four years many of the subjects required of all students, such as chemistry, mathematics and English, have doubled in attendance. The instruction force in these subjects, however, has very slightly increased. The consequence is that the teaching sections are inordinately large, — so large, in fact, that it is out of the question to get the best results of the teaching. These fundamental subjects, given to the students in the early years of their college course, should be given under the very best auspices, and one of the prime requisites is an ample teaching force, so that small sections may be the rule and so that no teacher shall be overworked. The close personal attention of first-class instructors in these subjects and at this time of the college course is vital to strong work on the part of the students. At least seven additional instructors are needed at once for work in chemistry, entomology, English, French and German, physics and mathematics.

The scope of our agricultural colleges is constantly broadening. Not many years have passed since a professor of agriculture and one or two assistants sufficed for instruction in agriculture; now there are numerous departments under the general name of agriculture, and we rarely find a professor of agriculture. In our own college during the past few years the professorship of horticulture has been broken up into professorships of landscape gardening, pomology, floriculture, market gardening and forestry. While we wish to avoid undue multiplication of departments, we must recognize new fields of work. At present the college gives no attention whatever to some very important branches of agricultural instruction. A State college of agriculture also has an obligation to turn out good citizens and well-rounded men. It is important, therefore, that we have

well-developed departments of economics, political science, etc. We ought to be able to establish next autumn departments of farm mechanics, bacteriology, poultry husbandry, economics and sociology, in addition to the instructorships already named. These important departures I realize cannot all be made even with an increase of \$15,000 a year additional for instruction; but they demonstrate the need of at least that much increase as a minimum.

Maintenance. — Increase, \$15,000. This increase would bring the item of maintenance and equipment to a total of \$88,000. While the treasurer's report shows a comfortable financial balance for the fiscal year, this balance was purchased at the sacrifice of several new departments which in justice to the students should have been established this last autumn. Not only have we new instructors and departments to provide for, but the large entomological building must be heated and lighted and cared for; the new buildings for animal husbandry and pomology will require similar support, and the increase in the number of students necessarily calls for some increased cost of maintenance. In order to provide for this natural growth it is necessary that the maintenance item shall be considered an essential appropriation.

Graduate School. — Increase, \$2,500. This increase was recommended last year. The graduate school is very important, but cannot be developed without more funds, and the amount asked for is exceedingly small for the purpose.

Normal Department. — Increase, \$5,000 a year. This department needs clerical help and additional instruction. The department had over 7,000 boys and girls in corn and potato clubs this past season, and this valuable work can be greatly — almost indefinitely — increased with the proper office help and supervision. The amount is the same as that asked last year.

Short Course and Extension Work. — Increase, \$15,000. The short course and extension work has grown very rapidly during the past year. Not less than 9,000 people were reached by the better-farming trains. Over 250 people are taking correspondence work in agriculture. Scores of lectures are given by our college teachers, and many more declined for lack of men to send. Demonstration orchards have been started in various

parts of the State, and many others are demanded. It is exceedingly important that we should be able to push a strong educational campaign in Massachusetts on behalf of dairy farms. We also want to take advantage of the new interest in corn growing. In some respects this extension work is the most important work of the college, because it reaches the great body of farmers directly with practical instruction and helps regarding modern methods of agriculture and horticulture.

Student Labor. — Increase, \$2,500 a year. This is needed because of the large increase in the number of students.

Agricultural Survey. — \$5,000 a year. The United States Department of Agriculture proposes to make a soil survey of the State, but insists upon our co-operation. In order to carry on in adequate fashion a comprehensive campaign of agricultural education in Massachusetts, it is necessary that we shall make an inventory of the agricultural resources of the State. We need a soil survey. We need to map the orchard lands and corn areas, to study farm management, to investigate the conditions that govern the sale of the farmers' products, and even to study the community life and institutions. In this way alone can we know thoroughly the real problems of Massachusetts agriculture and country life, and be prepared to give the very best advice. Some phases of this work are being done in many other States, and we should not lag behind. The willingness of the United States Department of Agriculture to co-operate places an obligation upon the State of Massachusetts.

Grounds. — \$5,000. This amount is needed annually for the development of roads, walks, drives, plantings and the general care of the same. The amount at present expended is in the neighborhood of \$2,000 a year, and is simply an up-keep, and, indeed, is not sufficient for that, and does not permit of any improvements whatever.

Repairs. — \$15,000 a year. I recommended in my last report that we should ask the Legislature for not less than \$15,000 a year for the purpose of the contingent repairs. This amount is about 3 per cent. of our inventoried valuation of buildings, and is by no means excessive. At present we are obliged to ask each Legislature for a special appropriation for this purpose.

pose. We could manage the matter in a much more business-like fashion, and relieve the Legislature of the necessity of going over small details, if we had this amount coming to us annually.

Equipment. — \$10,000 a year. The same arguments advanced for the permanent repair item apply to the permanent item of teaching equipment and apparatus for the various departments of the institution. It is expected that whenever a new building is erected a special appropriation shall be asked for to equip that building thoroughly. This item is intended to maintain the inventory of existing departments with respect to teaching equipment, apparatus, farm tools, live stock, etc., and is designed to take the place of the special legislative item for these purposes which goes to the Legislature each year.

Administration. — This item in the new classification represents the salaries and office expenses of the officers of the institution whose duties are largely or wholly administrative. It is also intended to include a small amount, perhaps \$5,000, which shall serve for emergencies of various types. The new classification will make it possible to present a more complete picture of the work of the institution and the expenditures of money, and I trust may be adopted by the Legislature.

Requests for Appropriations for Special Purposes.

Improvements, West Experiment Station Building. — \$7,500. This building has been quite outgrown by the development of experimental work in chemistry and by increase of inspection service devoted to fertilizers and feed stuffs. The experimental work particularly is seriously handicapped by this lack of room. Last year the Legislature was asked to appropriate \$28,000 for the enlargement of this building. It was thought at the time that the best plan would be to enlarge the building sufficiently to serve both the instruction work and the research work in chemistry. The appropriation was refused by the last Legislature, and the plans during the past summer were redrawn. Estimates obtained on the revised plans indicated that the amount of \$28,000 would not be enough to make the changes, and the trustees decided that under these circumstances

stances the best policy was to spend a comparatively small amount of money in some minor changes in the present building, and then plan for an entirely new building, to be asked for in the early future, for the purpose of housing the experiment station work in chemistry. It is thought that \$7,500 will make it possible to continue the inspection service in this building for many years to come, and will temporarily give relief to the research work in chemistry.

Enlargement of Draper Hall. — \$25,000. This improvement was asked for last year. The present dining hall barely accommodates the present number of students, and next autumn will undoubtedly be entirely too small for the probable number in attendance. When the building was erected less than 75 students took their meals at the dining hall. At the opening of this fall term nearly 350 students were taking their meals there, although the number has decreased somewhat since then; but during the ten weeks' winter school there will be a demand from 75 or 100 more men for boarding facilities. It is easily seen, therefore, that this is an improvement that is well-nigh imperative.

Dormitory. — \$20,000. At the present time the college is housing on the college campus about 75 out of its 400 students. It is difficult for students to find rooms in the village, and often the price that they are obliged to pay is beyond the ability of students who are working their way through college. A study has been made of the problem of securing a modern dormitory at a minimum cost. The plans as presented call for a well-built structure of pleasing architecture, with modern conveniences, the specifications showing that it can be built for an expenditure not exceeding \$400 per occupant. On this basis the trustees believe that it will be possible, at a rental to the students not to exceed \$1.25 per week, to heat the building, furnish janitor service, provide for future repairs, and still secure a return on the investment of at least 4 per cent.

Dairy Building and Equipment. — This appropriation was asked of the Legislature last year, the same amount and practically the same plan, \$75,000. The dairy industry is the largest single agricultural industry in the State of Massachusetts. It deserves special recognition by the Commonwealth, and particu-

larly on the educational side. This building will enable us to develop a thoroughly modern plant. The dairy work at the college is very popular, both with the regular and special students. The present facilities are wholly inadequate.

Department Equipment. — \$15,000. This item comprises miscellaneous teaching apparatus and office equipment for the various departments.

Repairs. — \$20,000. To be used for general repairs about the institution, — repairs of buildings, offices, heating and lighting plant, water system, sewer system, etc.

General Improvements. — \$25,000. This covers miscellaneous items as presented by the treasurer of the college and other various departments, such as small buildings for beekeeping, sheep sheds, storage building for plumbing and carpenter equipment, intercommunicating telephone system, improvements in the electric light plant, new sewers, etc.

Respectfully submitted,

KENYON L. BUTTERFIELD,

President.

AMHERST, Nov. 30, 1910.

STATISTICS OF THE COLLEGE.

TABLE I. — *Attendance.*

	For Year ending June 30, 1910.	For Year ending Nov. 30, 1910.
Graduate students,	18	15
Senior class,	45	47
Junior class,	50	87
Sophomore class,	91	110
Freshman class,	134	158
Unclassified students,	12	17
	— 350	— 434
Short courses: —		
Winter course, 1910,	64	64
Summer school,	176 ¹	229 ²
Bee course, 1910,	20	20
	— 260	— 313
Total,	610	747

¹ Summer of 1909.² Summer of 1910.TABLE II. — *Legislative Budget, 1910.*

ITEMS.	Amount asked.	Amount granted.
1. Special appropriations: —		
Maintenance expense,	\$18,000 00	\$18,000 00
Instruction,	5,000 00	2,500 00
Normal department,	1,250 00	—
Short courses,	4,375 00	625 00
Graduate school,	625 00	—
Grounds,	1,250 00	—
Equipment, entomological laboratory,	15,000 00	15,000 00
Repairs and improvements,	35,000 00	25,000 00
Teaching and office equipment,	15,000 00	10,000 00
Dairy building,	75,000 00	—
Enlargement of west experiment station building,	28,000 00	—
Building for animal husbandry,	10,000 00	10,000 00
Laboratory for pomology and market gardening,	16,000 00	12,000 00
Buildings for poultry husbandry,	5,000 00	5,000 00
Enlargement of Draper Hall,	23,000 00	—
Land,	25,000 00	17,500 00
	\$277,500 00	\$115,625 00
2. Increase in current annual appropriations: —		
Instruction,	\$20,000 00	\$10,000 00
Maintenance,	35,000 00	20,000 00
Graduate school,	2,500 00	—
Normal department,	5,000 00	—
Short courses,	17,500 00	7,500 00
Repairs,	15,000 00	—
Equipment,	10,000 00	—
Grounds,	5,000 00	—
	\$110,000 00	\$37,500 00

TABLE III. — *Speakers for the Year.**Speakers at Sunday Services for Year ending Nov. 30, 1910.*

1909.

- Dec. 5. — Dr. Samuel A. Eliot, Boston.
Dec. 12. — Rev. A. P. Record, Springfield.

1910.

- Jan. 9. — Bishop Alexander H. Vinton, Springfield.
Jan. 16. — Rev. Philip S. Moxom, Springfield.
Jan. 23. — Rev. Herbert J. White, Hartford, Conn.
Feb. 13. — Rev. Charles F. Carter, Lexington.
Feb. 20. — Rev. Charles S. Macfarland, South Norwalk, Conn.
Feb. 27. — Rev. Albert P. Fitch, Cambridge.
Mar. 6. — President Kenyon L. Butterfield.
Mar. 13. — Dr. F. E. Emrich, Boston.
Mar. 20. — Rev. James DeNormandie, Roxbury.
Sept. 18. — President Kenyon L. Butterfield.
Sept. 25. — Mr. John Y. Beattie, Springfield.
Oct. 2. — Mr. Robert L. O'Brien, Boston.
Oct. 9. — Dr. Warren H. Wilson, New York.
Oct. 16. — Mr. Albert E. Roberts, New York.
Oct. 23. — Mr. Charles H. White, Amherst.
Oct. 30. — Dr. R. DeWitt Mallery, Springfield.
Nov. 6. — Rev. F. E. Tower, Albany, N. Y.
Nov. 13. — Hon. Frank A. Hosmer, Amherst.
Nov. 20. — Hon. Henry Bond, Greenfield.

Speakers at Wednesday Assemblies for Year ending Nov. 30, 1910.

1909.

- Dec. 8. — Dean Eugene Davenport, Urbana, Ill.

1910.

- Jan. 26. — Dr. W. I. Chamberlain, Hudson, O.
Feb. 9. — Dr. Benjamin A. Trueblood, Boston.
Feb. 16. — Prof. John S. Bassett, Northampton.
Feb. 23. — Mrs. Mabel Loomis Todd, Amherst.
Mar. 16. — Dr. Winfield Ayres, New York.
April 6. — Mr. M. V. Richards, Washington, D. C.
April 27. — Dr. David Snedden, Boston.
May 4. — Mr. Edward Porritt, Hartford, Conn.
May 18. — Mr. Henry Wallace, Des Moines, Ia.
May 25. — Mr. Frederick P. Fish, Boston.
Oct. 5. — Mr. C. T. Wang, New Haven, Conn.
Oct. 19. — Dr. John Graham Brooks, Cambridge.
Oct. 26. — Dr. Joel E. Goldthwait, Boston.
Nov. 9. — Prof. Frank A. Waugh, Amherst.
Nov. 30. — Capt. George C. Martin, Amherst.

TABLE IV.—*Statistics of Freshmen entering College in September, 1910.*(A) *Home Addresses (classified by Towns and Cities).*

Agawam,	1	Lawrence,	2	Quincy,	1
Amherst,	3	Lee,	1	Raynham,	1
Arlington,	2	Leominster,	1	Rutherford, N. J.,	1
Bangor, Me.,	1	Lincoln,	1	Salem,	3
Belchertown,	1	Littleton,	2	Sandwich,	1
Blackstone,	1	Lowell,	3	Shanghai, China,	1
Boston,	17	Lynn,	1	Sheffield,	1
Brimfield,	1	Malden,	4	Sherborn,	1
Brockton,	4	Marshalltown, Ia.,	1	Somerville,	1
Brookline,	1	Marshfield,	1	Southbridge,	1
Brown Station, N. Y.,	1	Mattapoisett,	1	Southbury, Conn.,	1
Cambridge,	1	Medford,	1	South Framingham,	3
Cataumet,	1	Medway,	1	South Hadley Falls,	2
Concord,	2	Melrose,	2	South Hanson,	1
Dedham,	1	Mendon,	2	Springfield,	3
Duxbury,	1	Methuen,	1	Stafford Springs, Conn.,	1
Easton,	1	Monson,	1	Sunderland,	2
Everett,	1	Morristown, Pa.,	1	Taunton,	1
Fall River,	2	Mount Kisco, N. Y.,	1	Templeton,	1
Gilbertville,	1	Mount Vernon, N. Y.,	1	Tolland,	1
Glen Cove, L. I.,	1	New Bedford,	1	Townsend,	1
Granby,	1	New Braintree,	1	Truro,	1
Greenfield,	1	New Haven, Conn.,	1	Wakefield,	1
Groton,	1	New London, Conn.,	1	Walpole,	1
Hadley,	1	Newton,	1	Waltham,	1
Hanson,	1	New York, N. Y.,	3	Ware,	1
Haverhill,	1	North Adams,	2	Wareham,	1
Hingham,	1	Northampton,	3	Watertown,	1
Holliston,	1	North Weymouth,	1	Wellesley,	1
Holyoke,	1	Oxford,	1	West Burke, Vt.,	1
Huntington, L. I.,	1	Palmer,	1	West Somerville,	2
Hyannis,	1	Peabody,	2	West Springfield,	2
Hyde Park,	1	Philadelphia, Pa.,	1	Wethersfield, Conn.,	1
Irvington-on-Hudson, N. Y.,	1	Plymouth,	1	Winthrop,	2
Kingston, R. I.,	1	Poquonock, Conn.,	1	Worcester,	2
Lancaster,	1	Portsmouth, N. H.,	1		

(B) *Home Addresses (classified by Countries and States).*

	Number.	Per Cent.		Number.	Per Cent.
China,	1	.63	New Jersey,	1	.63
Connecticut,	6	3.80	New York,	9	5.70
Iowa,	1	.63	Pennsylvania,	2	1.26
Maine,	1	.63	Rhode Island,	1	.63
Massachusetts,	134	84.81	Vermont,	1	.63
New Hampshire,	1	.63			
				158	99.98

(C) *Home Addresses (classified by Counties of Massachusetts).*

	Number.	Per Cent.		Number.	Per Cent.
Barnstable,	5	3.72	Hampshire,	12	8.95
Berkshire,	3	2.24	Middlesex,	32	23.13
Bristol,	6	4.48	Nantucket,	—	—
Dukes,	—	—	Norfolk,	8	5.96
Essex,	10	7.43	Plymouth,	11	8.19
Franklin,	3	2.24	Suffolk,	19	14.15
Hampden,	13	9.67	Worcester,	12	8.95
				134	99.11

(D) Nativity of Parents.

	Number.	Per Cent.
Neither parent foreign born,	117	74.05
Both parents foreign born,	25	15.82
Mother foreign born,	14	8.86
Father foreign born,	2	1.26
	158	99.99

(E) Education of Father.

	Number.	Per Cent.
Common school,	79	50
High school,	46	29.11
Business school,	8	5.06
College,	21	13.29
Deceased and no statistics,	4	2.53
	158	99.99

(F) Religious Census.

DENOMINATION.	MEMBERSHIP.		PREFERENCE.		TOTALS.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist,	9	5.70	4	2.53	13	8.23
Catholic,	15	9.49	—	—	15	9.49
Congregational,	37	23.42	22	13.92	59	37.34
Episcopal,	13	8.23	4	2.53	17	10.76
Methodist,	9	5.70	5	3.16	14	8.86
Miscellaneous,	5	3.16	8	5.06	13	8.23
Presbyterian,	4	2.53	—	—	4	2.53
Unitarian,	6	3.80	8	5.06	14	8.86
Universalist,	3	1.90	6	3.80	9	5.70
	101	63.93	57	36.06	158	100.00

(G) Occupation of Fathers.

	Number.	Per Cent.
Agriculture and horticulture,	37	23.42
Artisans,	30	13.98
Business,	48	30.37
Deceased,	11	6.97
Miscellaneous,	18	11.40
Professional,	11	6.97
Retired,	3	1.90
	158	100.01

(H) Intended Vocations of Students.

	Number.	Per Cent.
Agriculture and horticulture (practical),	60	37.96
Agriculture and horticulture (professional),	52	32.91
Engineering,	9	5.70
Professions,	2	1.26
Undecided,	35	21.16
	158	99.99

(I) Farm Experience.

	Number.	Per Cent.
Brought up on a farm,	43	27.22
Not brought up on a farm,	115	72.79
Not brought up on a farm but having had some farm experience,	59	37.34

(J) Miscellaneous Statistics.

Average age,	19.07 years.
Number applying for student labor,	92, 58.22 per cent.
Number boarding at Draper Hall,	142, 89.87 per cent.

TABLE V.—Loans and Gifts.

Massachusetts Experiment Station.—List of Gifts for the Year ending Nov. 1, 1910.

Park & Pollard Co., 46 Canal Street, Boston,	2 lullaby brooders.
J. A. Jocoy, 701 Second Street, Towanda, Pa.,	1 Jocoy's poultry food hopper.
Bolgiano & Son, Baltimore, Md.,	1 packet seed "My Maryland" tomato.
	1 ton muriate of potash.
German Kali Works, Baltimore, Md.,	1 ton high-grade sulfate of potash.
	1 ton sulfate of potash-magnesia.
	200 pounds kainit.
American Coal Products Co., 17 Battery Place, New York,	300 pounds sulfate of ammonia.
	100 pounds Hubbard's raw knuckle bone flour.
Rogers & Hubbard, Middletown, Conn.,	100 pounds Hubbard's dissolved bone black.
20th Century Co., Boston, Mass.,	3 pounds superfine ground granitic rock.

Library. — List of Gifts for Two-Year Period, ending Nov. 30, 1910.

Allen, Dr. E. W., Washington, D. C.,	Complete set of "Experiment Station Record."
Brooks, Dr. William P., Amherst,	Agricultural periodicals and magazines.
Carruth, Herbert S., Boston,	Fifteen volumes relating to flora and fauna of New Zealand.
Chapman, George H., Amherst,	Experiment station bulletins.
Clark, Mrs. Milford H., Sunderland,	Magazines and books.
Crane, Hon. W. Murray, Dalton,	History of the United States capitol, 2 volumes.
Fernald, Prof. Charles H., Amherst,	Scientific contributions and college publications.
Fowler, F. H., Boston,	Agricultural bulletins and reports.
Gage, Mrs. A. E., Woburn,	"American Review of Reviews," 16 volumes.
Henry, Mrs. George, Amherst,	Magazines and books.
Hosmer, Hon. Frank A., Amherst,	Public documents.
Howard, Prof. S. Francis, Amherst,	Magazines and newspaper clippings.
Lodge, Hon. Henry Cabot, Nahant,	Congressional documents.
Mills, Prof. George F., Amherst,	Magazines.
Mills, James K., Amherst,	Books, photographs and magazines.
Osmun, Prof. A. V., Amherst,	Agricultural bulletins and magazines.
Raymond, Prof. George L., Princeton, N. J.,	Ten volumes on "Comparative Esthetics."
Stone, Dr. George E., Amherst,	Magazines.
Superintendent of Documents, Washington, D. C.,	American Historical Association reports, document catalogues, and United States public documents.
United States Department of Agriculture, Washington, D. C.,	Complete set of Farmers' bulletins, and numerous other publications.
Walker, Dr. C. S., Amherst,	Newspaper clippings and pamphlets.
Waugh, Prof. F. A., Amherst,	Magazines and books.
Williams, Mrs. Mary E., Amherst,	Books.

Special mention is gladly made concerning the large number of botanical and horticultural books recently given to the library by Mr. George C. Woolson, 1871, of Yonkers, N. Y. The larger part of the collection belonged originally to Mr. Woolson's brother-in-law, the late Dr. George Thurber, a botanist of wide reputation, and whom Dr. Sargent of Harvard described as the most accomplished horticultural writer in the country.

In presenting these books to the library Mr. Woolson gives them as a memorial to the class of 1871, and this idea is to be conveyed by the special bookplate which is to be made for this collection. A detailed description of this splendid gift of about 1,200 volumes cannot be made at this time, but it is intended to publish something of that nature in one of the college publications at an early date.

REPORT OF TREASURER

FOR THE FISCAL YEAR ENDING NOV. 30, 1910.

BALANCE SHEET.

		DR.	CR.
1909.			
Dec. 1.	To cash on hand,	\$4,106 58	
	To cash on deposit,	10,813 84	
1910.			
Nov. 30.	To special appropriation receipts, State Treasurer, . . .	121,152 88	
	By special appropriation disbursements,		\$121,933 47
	To experiment station receipts,	60,791 90	
	From State Treasurer, \$13,500 00		
	From United States Treasurer 29,000 00		
	From other sources, 18,291 90		
	By experiment station disbursements,		61,674 64
	To current accounts receipts,	193,029 03	
	From United States Treasurer, Morrill fund, \$16,666 67		
	From United States Treasurer, Nelson fund, 13,333 33		
	From State Treasurer, endowed fund, 10,613 32		
	From State Treasurer, maintenance, 33,000 00		
	From State Treasurer, scholarship, 15,000 00		
	From State Treasurer, instruction, 40,000 00		
	From State Treasurer, Extension department, 8,125 00		
	From State Treasurer, agricultural education, 5,000 00		
	From State Treasurer, veterinary, 1,000 00		
	From State Treasurer, student labor, 7,500 00		
	From other sources, 42,790 71		
	By current account disbursements,		182,693 14
	To student trust funds receipts,	57,571 79	
	By student trust funds disbursements,		55,777 37
	To experiment station trust funds receipts,	728 87	
	By experiment station trust funds disbursements,		471 47
	By cash on hand,		5,664 38
	By cash on deposit,		19,980 42
		\$448,194 89	\$448,194 89

STATEMENT OF THE FIRST NATIONAL BANK OF AMHERST WITH THE
MASSACHUSETTS AGRICULTURAL COLLEGE.

		Dr.	Cr.
1909.			
Dec. 1.	Balance on hand,	\$25,986 26 ¹	
1910.			
Nov. 30.	Deposits,	474,029 15	
	Interest,	264 29	
	Disbursements as per warrants paid,		\$460,111 23
	Balance on hand,		40,168 47 ¹
		\$500,279 70	\$500,279 70

¹ These amounts are greater Dec. 1, 1909, by \$15,172.42, and Nov. 30, 1910, by \$20,155.11, on account of outstanding checks.

SPECIAL APPROPRIATIONS.

NAME OF APPROPRIATION.	Date made.	Amount of Appropriation.	Amount previously expended.	Amount expended during Fiscal Year.	Amount expended to Date.	Amount received from State Treasurer.	Balance on Hand with State Treasurer.
Athletic field,	1909	\$5,500 00	\$4,761 10	\$738 90	\$5,500 00	\$5,500 00	-
Replacing barn,	1909	30,000 00	19,187 48	13,689 04	32,876 52	30,000 00	-
Repairs and improvements,	1909	33,000 00	24,620 84	8,683 93	33,254 77	33,254 77	-
Teaching equipment,	1909	10,000 00	4,267 28	5,738 72	10,337 40	10,337 40	-
Zoological building,	1909	80,000 00	16,390 31	50,380 72	66,771 03	66,771 03	\$13,246 32
Animal husbandry building,	1910	10,000 00	-	4,166 35	4,166 35	3,975 21	6,024 79
Investigation as to cranberry growing,	1910	15,000 00	-	63 06	63 06	63 06	14,936 94 ²
Laboratory for pomology,	1910	12,000 00	-	1,223 38	1,223 38	1,223 38	10,776 62
Land,	1910	17,500 00	-	11,797 11	11,797 11	11,797 11	65 98 ³
Repairs and improvements,	1910	25,000 00	-	16,640 06	16,640 06	15,113 95	9,881 05
Teaching and office equipment,	1910	10,000 00	-	2,984 13	2,984 13	2,494 51	7,505 49
Equipment for laboratory, entomology and zoölogy,	1910	15,000 00	-	5,872 19	5,872 19	5,066 67	9,933 33
		\$263,000 00	\$69,227 01	\$121,927 59	\$191,486 00	\$185,692 09	\$72,370 52

¹ There is a credit of \$2,200 under farm buildings to take care of this amount.² From this amount should be taken \$12,738.35 paid direct by State Treasurer.³ This amount was lessened by \$5,636.91 being paid direct by State Treasurer.

CURRENT ACCOUNTS.

Disbursements and Receipts.

ACCOUNTS.	Disbursements from Dec. 1, 1909, to Nov. 30, 1910.	Receipts from Dec. 1, 1909, to Nov. 30, 1910.	Apportionment for Year ending Nov. 30, 1910.	Balance to Credit.
Architects' fees,	\$3,155 44 ¹	—	—	—\$3,155 44
Administration,	4,729 04	\$30 07	\$5,010 00	310 96
Agricultural,	22,028 79	16,339 90	5,825 00	136 11
Agricultural economics,	112 60	—	50 00	—62 60
Agricultural education,	5,047 21	15 91	5,000 00	—31 30
Botanical,	994 05	259 34	700 00	—34 71
Chemical,	2,137 73	2,075 14	1,000 00	937 41
Dean's office,	232 36	36	200 00	—32 00
Entomology,	515 29	251 61	725 00	461 32
English,	539 69	1 00	855 00	316 31
Extension department,	12,336 03	1,745 63	8,125 00	—2,465 40
Floriculture,	2,987 80	2,495 93	1,250 00	758 13
General horticulture,	2,436 18	805 51	1,800 00	169 33
General maintenance,	32,405 40	10,739 37	30,700 00	9,033 97
Graduate school,	1,413 19	—	2,500 00	1,086 81
Grounds,	1,444 30	54 10	1,200 00	—190 20
Library,	5,083 89	567 51	4,575 00	58 62
Landscape gardening,	258 21	123 90	100 00	—34 31
Market gardening,	4,970 60	2,604 94	2,100 00	—265 66
Mathematics and physics,	251 74	1 12	400 00	149 38
Military,	1,657 52	53 25	1,500 00	—104 27
Options on land,	125 00	115 00	—	—10 00
Physical education,	566 41	137 85	530 00	101 44
Political science,	7 05	—	10 00	2 95
Pomology,	3,237 78	1,398 70	1,850 00	10 92
President's office,	721 91	15 25	800 00	93 34
Registrar,	249 12	—	300 00	50 88
Salaries,	71,124 91	143 32	70,950 00	—31 59
Treasurer's office,	753 75	34 69	675 00	—44 06
Veterinary,	777 42	5 90	1,542 97 ²	771 45
Zoological,	392 73	275 41	20 00	—97 32
State Treasurer: —				
Endowment fund,	—	10,613 32	—	—
Instruction fund,	—	40,000 00	—	—
Maintenance fund,	—	33,000 00	—	—
Student labor fund,	—	7,500 00	—	—
Scholarship fund,	—	15,000 00	—	—
Extension department,	—	8,125 00	—	—
Agricultural education,	—	5,000 00	—	—
Veterinary,	—	1,000 00	—	—
Graduate school,	—	2,500 00	—	—
United States Treasurer: —				
Morrill fund,	—	16,666 67	—	—
Nelson fund,	—	13,333 33	—	—
Balance beginning fiscal year, Dec. 1, 1909,	\$182,693 14	\$193,029 03	\$150,292 97	\$14,449 33
Balance on hand Nov. 30, 1910,	22,055 78	—	—	—6,558 86
	\$204,748 92	\$204,748 92	\$150,292 97	\$7,890 47

¹ Architects' fees are on account of the cost of the preparation of plans and specifications for use of Legislature, but on account of no appropriation being made this expense was paid from the current funds.

² Includes balance brought forward Dec. 1, 1909, \$542.97.

Summary.

	Disbursements.	Receipts.
By cash on hand Dec. 1, 1909,	-	\$11,719 89
By institution receipts Nov. 30, 1910,	-	40,290 71
By State Treasurer receipts Nov. 30, 1910,	-	122,738 32
By United States Treasurer receipts Nov. 30, 1910,	-	30,000 00
To total disbursements Nov. 30, 1910,	\$182,693 14	-
Bills receivable Dec. 1, 1909, deducted,	\$182,693 14	\$204,748 92
Bills payable Dec. 1, 1909, deducted,	1,724 68	4,558 07
	\$180,968 46	\$200,190 85
Bills receivable Nov. 30, 1910,	-	2,187 72
Bills payable Nov. 30, 1910,	1,668 77	-
Balance,	19,741 34	-
	\$202,378 57	\$202,378 57

Comparative Disbursements and Receipts for 1909-10.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1909.	1910.	1909.	1910.
Architects' fees,	-	\$3,155 44	-	-
Administration,	\$5,041 39	4,729 04	\$173 15	\$30 07
Agriculture,	19,697 34	22,028 79	14,271 77	16,339 90
Agricultural economics,	6 95	112 60	-	-
Agricultural education,	5,204 17	5,047 21	13 90	15 91
Botanical,	1,320 99	994 05	611 90	259 34
Chemical,	3,152 00	2,137 73	1,775 82	2,075 14
Dean's office,	201 17	232 36	-	36
Entomology,	651 31	515 29	224 87	251 61
English,	372 37	539 69	-	1 00
Extension work,	6,206 95	12,336 03	1,475 27	1,745 63
Floriculture,	2,398 65	2,987 80	1,484 65	2,495 93
Farm fire,	-	-	2,469 64	-
General horticulture,	2,992 94	2,436 18	1,183 34	805 51
General maintenance,	33,518 04	32,405 40	11,162 75	10,739 37
Graduate school,	397 68	1,413 19	-	-
Grounds,	1,474 61	1,444 30	16 30	54 10
Library,	3,659 38	5,083 89	422 48	567 51
Landscape gardening,	231 62	258 21	162 00	123 90
Market gardening,	4,775 49	4,970 60	2,914 03	2,604 94
Mathematics and physics,	251 71	251 74	-	1 12
Meteorology,	65 20	-	-	-
Military,	943 75	1,657 52	126 87	53 25
Options on land,	-	125 00	-	115 00
Physical education,	149 77	566 41	-	137 85
Political science,	-	7 05	-	-
Pomology,	2,943 64	3,237 78	1,472 29	1,398 70
President's office,	832 58	721 91	63 29	15 25
Registrar,	176 61	249 12	-	-
Salaries,	63,353 96	71,124 91	-	143 32
Treasurer's office,	492 18	753 75	24 27	34 69
Veterinary,	1,042 00	777 42	148 00	5 90
Zoölogical,	237 97	392 73	322 60	275 41
State Treasurer: —				
Agricultural education,	-	-	6,250 00	5,000 00
Endowment fund,	-	-	10,613 32	10,613 32
Graduate school,	-	-	-	2,500 00
Heat and light,	-	-	625 00	-
Instruction,	-	-	35,750 00	40,000 00
Maintenance,	-	-	15,000 00	33,000 00
Extension department,	-	-	6,250 00	8,125 00
Scholarship fund,	-	-	18,750 00	15,000 00
Student labor,	-	-	-	7,500 00
Veterinary,	-	-	1,250 00	1,000 00
United States Treasurer: —				
Morrill fund,	-	-	16,666 67	16,666 67
Nelson fund,	-	-	10,000 00	13,333 33
	\$161,792 42	\$182,693 14	\$161,674 18	\$193,029 03
Balance beginning fiscal year,	-	-	11,838 13	11,719 89
Balance at close,	11,719 89	22,055 78	-	-
	\$173,512 31	\$204,748 92	\$173,512 31	\$204,748 92

EXPERIMENT STATION.

Disbursements and Receipts.

ACCOUNTS.	Disbursements from Dec. 1, 1909, to Nov. 30, 1910.	Receipts from Dec. 1, 1909, to Nov. 30, 1910.	Apportionment for Year ending Nov. 30, 1910.	Balance to Credit.
Administration,	\$1,722 57	\$32 80	\$2,000 00	\$310 23
Agricultural,	5,286 14	2,963 67	2,500 00	177 53
Asparagus,	736 59	—	700 00	—36 59
Botanical,	1,283 19	28 70	1,600 00	345 51
Chemical,	9,228 18	6,660 08	2,800 00	231 90
Cranberry,	1,504 29	1,958 54	1,000 00	1,454 25
Entomological,	562 81	1 20	800 00	238 39
Fertilizer,	—	5,880 00	—	5,880 00
Freight,	445 03	85	500 00	55 82
Graves orchard,	350 81	119 00	300 00	68 19
Horticultural,	1,530 18	2 37	1,450 00	—77 81
Library,	289 62	—	300 00	10 38
Meteorology,	299 03	—	300 00	97
Publications,	1,953 86	—	3,200 00	1,246 14
Salaries,	31,438 00	15 52	31,825 36	402 88
Treasurer's office,	370 74	—	400 00	29 26
Veterinary,	218 64	—	250 00	31 36
Hatch fund,	—	15,000 00	—	—
Adams fund,	—	14,000 00	—	—
State fund,	—	10,500 00	—	—
Feed law,	3,580 61	3,000 00	5,148 50	1,567 89
Cranberry association, ¹	544 17	544 17	—	—
Expert services,	12 40	85 00	—	72 60
Tobacco investigations,	317 78	—	400 00	82 22
	\$61,674 64	\$60,791 90	\$55,473 86	\$12,205 52
Balance beginning fiscal year, Dec. 1, 1909,	—	6,682 68	—	—114 40
Balance on hand Nov. 30, 1910,	5,799 94	—	—	—
	\$67,474 58	\$67,474 58	\$55,473 86	\$12,091 12

¹ Transferred to cranberry growers' contribution account.*Experiment Station Trust Fund.*

Account.	Disbursements for Year ending Nov. 30, 1910.	Receipts for Year ending Nov. 30, 1910.	Balance on Hand.
Cranberry growers' contribution,	\$471 47	\$728 87	\$257 40

Comparative Disbursements and Receipts for 1909-10.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1909.	1910.	1909.	1910.
Administration,	\$2,065 20	\$1,722 57	\$47 35	\$32 80
Agricultural,	4,578 09	5,286 14	2,010 46	2,963 67
Asparagus,	715 60	736 59	—	—
Botanical,	1,617 96	1,283 19	44 13	28 70
Chemical,	9,403 73	9,228 18	4,809 38	6,660 08
Cranberry,	459 56	1,504 29	—	1,958 54
Entomological,	495 58	562 81	—	1 20
Fertilizer,	—	—	5,505 00	5,880 00
Freight,	499 91	445 03	15 29	85
Graves orchard,	281 10	350 81	—	119 00
Horticultural,	1,719 44	1,530 18	1 15	2 37

Comparative Disbursements and Receipts for 1909-10 — Concluded.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1909.	1910.	1909.	1910.
Library,	\$343 11	\$289 62	\$8 87	—
Meteorology,	308 05	299 03	—	—
Publications,	2,031 81	1,953 86	107 98	—
Salaries,	27,842 23	31,438 00	153 08	\$15 52
Treasurer's Office,	319 82	370 74	—	—
Veterinary,	231 71	218 64	—	—
Hatch fund,	—	—	15,000 00	15,000 00
Adams fund,	—	—	12,000 00	14,000 00
State fund,	—	—	13,125 00	10,500 00
Feed law,	3,011 51	3,580 61	4,500 00	3,000 00
Repairs,	1 30	—	—	—
Cranberry Association, ¹	—	544 17	—	544 17
Expert services,	—	12 40	—	85 00
Tobacco investigations,	—	317 78	—	—
<i>Is</i>	\$55,925 71	\$61,674 64	\$57,327 69	\$60,791 90
Balance beginning fiscal year,	—	—	5,280 70	6,682 68
Balance on hand Nov. 30, 1910,	6,682 68	5,799 94	—	—
	\$62,608 39	\$67,474 58	\$62,608 39	\$67,474 58

¹ Transferred to cranberry growers' contribution account.

AGRICULTURAL DIVISION.

Disbursements and Receipts for Fiscal Year ending Nov. 30, 1910.

	Disbursements.	Receipts.
<i>Academic.</i>		
Maintenance,	\$99 74	\$0 64
Equipment,	114 99	7 76
Student labor,	133 11	45
Miscellaneous,	140 76	1 50
Department totals,	\$488 60	\$10 35
Office,	\$215 55	\$22 79
<i>Farm.</i>		
Labor,	\$9,378 12	\$3,139 52
Dairy,	1,568 73	3,839 85
Teams,	1,353 26	27 00
Cattle,	4,559 02	7,352 65
Horses,	494 92	57 50
Swine,	213 25	377 47
Field Crops,	1,180 45	1,444 97
Repairs,	268 11	—
Improvements,	178 62	46 80
Student labor,	1,719 83	11 25
Sundry,	142 29	9 75
Tools,	268 04	—
Department totals,	\$21,324 64	\$16,306 76
Division totals,	\$22,028 79	\$16,339 90

AGRICULTURAL DIVISION — *Concluded.**Summary.*

	Dr.	Cr.
By total division receipts,		\$16,339 90
By bills receivable,		1,136 49
By net apportionment,		5,825 00
To total disbursements,	\$22,028 79	
To bills payable,	499 74	
To balance,	772 86	
	\$23,301 39	\$23,301 39

Inventory of Quick Assets.

	Nov. 30, 1909.	Nov. 30, 1910.
Inventory of produce,	\$3,219 93	\$4,999 13
Inventory of cattle,	8,155 00	10,042 00
Inventory of swine,	182 00	340 00
Inventory of horses,	4,375 00	4,400 00
	\$15,931 93	\$19,781 13

HORTICULTURAL DIVISION.

Disbursements and Receipts for Fiscal Year ending Nov. 30, 1910.

	Disbursements.	Receipts.
Market gardening,	\$4,970 60	\$2,604 94
General horticulture,	2,436 18	805 51
Floriculture,	2,987 80	2,495 93
Pomology,	3,237 78	1,398 70
Landscape gardening,	258 21	123 90
Totals,	\$13,890 57	\$7,428 98

Summary.

	Dr.	Cr.
By total division receipts,		\$7,428 98
By bills receivable,		883 70
By apportionment,		7,100 00
To total division disbursements,	\$13,890 57	
To total division bills payable,	122 93	
To balance unexpended,	1,399 18	
	\$15,412 68	\$15,412 68

Inventory of Quick Assets.

	Nov. 30, 1909.	Nov. 30, 1910.
Inventory of produce,	\$410 40	\$496 00

INVENTORY — REAL ESTATE.

Land (Estimated Value).

Baker place,	\$2,500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
College farm,	37,000 00	
Harlow farm,	3,284 63	
Kellogg farm,	5,868 45	
Louisa Baker place,	5,636 91	
Old creamery place,	1,726 25	
Pelham quarry,	500 00	
Westcott place,	2,250 00	
Allen place,	500 00	
Charmbury place,	450 00	
Loomis place,	415 00	
Hawley & Brown place,	675 00	\$67,656 24

College Buildings (Estimated Value).

Chemical laboratory,	\$8,200 00	
Clark hall,	67,400 00	
Dining hall,	35,450 00	
Drill hall,	7,000 00	
Durfee plant house and fixtures,	10,000 00	
Dwelling houses purchased with farm,	5,100 00	
Entomology building,	80,000 00	
Farmhouse,	2,050 00	
French hall,	17,000 00	
Glass house range,	15,000 00	
Graves house and barn,	1,560 00	
Gun shed and bath room,	2,500 00	
Hay storage barn and silo,	30,000 00	
Horse barn,	5,020 00	
Horticultural barn,	2,525 00	
Insectary,	5,800 00	
Mathematical building,	5,600 00	
North dormitory,	25,400 00	
Power house,	13,000 00	
Powder house,	75 00	
President's house,	12,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
South dormitory,	35,500 00	
Stone chapel,	30,225 00	
Tool house,	2,000 00	
Veterinary laboratory and stable,	22,995 60	
Wilder Hall,	37,300 00	
Young stock barn,	6,500 00	
		<hr/> 489,900 60
Amount carried forward,		\$557,556 84

College Equipment (Estimated Value).

<i>Amount brought forward,</i>	\$557,556	84
Agricultural division:—		
Academic,	\$3,742	14
Dairy school,	1,735	14
Farm,	27,053	84
Agricultural education,	607	21
Botanical department,	7,468	47
Chemical laboratory,	4,634	50
College supplies,	146	05
Dean's office,	277	80
Dining hall,	3,029	63
Entomological laboratory,	4,158	15
Extension department,	952	05
Fire apparatus,	623	20
Floriculture,	5,690	73
General horticulture,	8,603	55
General maintenance,	64,369	57
Landscape gardening,	4,286	65
Language and literature,	189	01
Library,	54,679	55
Market gardening,	699	00
Military,	1,153	80
Pomology,	1,335	43
Physical education,	2,136	04
Physics and mathematics,	5,679	50
President's office,	938	83
Registrar's office,	292	20
Treasurer's office,	926	00
Trophy room,	1,273	85
Veterinary laboratory,	7,879	97
Water mains,	7,810	00
Zoölogical laboratory,	8,647	79
Zoölogical museum,	5,689	73
	<hr/>	
	236,709	38

Experiment Station Buildings (Estimated Value).

Agricultural laboratory,	\$9,000 00	
Chemical laboratory (plant and animal chemistry), .	20,000 00	
Entomological laboratory,	850 00	
	<u> </u>	29,850 00

Experiment Station Equipment (Estimated Value).

Agricultural laboratory,	.	.	.	.	.	\$7,303 65	
Botanical laboratory,	.	.	.	.	.	4,193 44	
Chemical laboratory,	.	.	.	.	.	19,661 18	
Director's office,	.	.	.	.	.	3,200 50	
Entomological laboratory,	.	.	.	.	.	21,904 15	
Horticultural laboratory,	.	.	.	.	.	1,058 20	
Meteorology laboratory,	.	.	.	.	.	1,304 80	
Treasurer's office,	.	.	.	.	.	480 50	
							59,106 42
							\$883,222 64

Inventory Summary.

Land,	\$67,656 24
College buildings,	489,900 60
College equipment,	236,709 38
Experiment station buildings,	29,850 00
Experiment station equipment,	59,106 42
	<hr/> \$883,222 64

STUDENTS' TRUST FUNDS ACCOUNTS.

ACCOUNTS.	Disburse- ments for Year ending Nov. 30, 1910.	Receipts for Year ending Nov. 30, 1910.	Balance brought for- ward Dec. 1, 1909.	Balance on Hand Nov. 30, 1910.
Athletics,	\$2,116 88	\$4,676 79	\$10 00	\$2,569 91
Dining hall,	41,698 17	40,910 28	-5,658 36	-6,446 25
College signal,	1,549 98	1,629 86	333 20	413 08
Keys,	48 25	43 50	33 75	29 00
Creamery house,	167 76	184 43	24 54	41 21
Student deposits,	3,539 42	3,266 15	447 63	174 36
Harlow farm,	287 78	302 77	-42 51	-27 52
Trophy room tax,	790 99	702 97	364 25	276 23
Kellogg farm,	327 21	417 75	-22 42	68 12
Text-books,	3,627 19	3,577 56	1,154 22	1,104 59
Uniforms,	1,551 28	1,755 20	1,527 78	1,731 70
Musical association,	72 46	79 53	23 75	30 82
Louisa Baker farm,	-	25 00	188 14	213 14
	<hr/> \$55,777 37	<hr/> \$57,571 79	<hr/> -\$5,723 29	<hr/> \$6,652 16
Balance on hand Dec. 1, 1909,	1,616 03	-	4,107 26	-6 473 77
Balance on hand Nov. 30, 1910,	-	178 39	-	-
	<hr/> \$57,393 40	<hr/> \$57,393 40	<hr/> -\$1,616 03	<hr/> \$178 39

DETAILED STATEMENT OF DINING HALL.

	Liabilities.	Resources.
Dec. 1, 1909, cash overdraft,	\$5,658 36	-
Nov. 30, 1910, provisions purchased,	41,698 17	-
Nov. 30, 1910, outstanding bills,	1,224 11	-
Nov. 30, 1910, total collections,	-	\$40,910 28
Nov. 30, 1910, total collections outstanding,	-	2,856 26
Nov. 30, 1910, inventory,	-	2,922 89
Balance,	-	1,891 21
	<hr/> \$48,580 64	<hr/> \$48,580 64

ENDOWMENT FUND.¹

	Principal.	Income.
United States grant (5 per cent.),	\$219,000 00	\$7,300 00
Commonwealth grant (3½ per cent.),	142,000 00	3,313 32
		<hr/> \$10,613 32

¹ This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

BENEFICIARY FUNDS.

Burnham Emergency Fund.

	Market Value Dec. 1, 1910.	Par Value.	Income.
Two Lake Shore & Michigan Southern Railroad gold notes, at \$1,000,*	-	\$2,000 00	\$50 00
Two bonds American Telephone and Telegraph Company 4s, at \$910.	\$1,820 00	2,000 00	80 00
Two bonds Western Electric Company 5s, at \$1,000, . . .	2,000 00	2,000 00	50 00
One bond United Fruit Company 5s,	1,010 00	1,000 00	50 00
	\$4,830 00	\$7,000 00	\$230 00
*On Feb. 1, 1910: —			
Two Lake Shore & Michigan Southern Rail- road bonds were sold for . . . \$2,000 00	-	-2,000 00	-
Two Western Electric Company bonds were purchased for 1,996 67	-	-	3 33
Unexpended balance Dec., 1909,	-	-	382 62
	\$4,830 00	\$5,000 00	\$615 95
Disbursements for fiscal year ending Nov. 30, 1910, . . .	-	-	215 05
Cash on hand Dec. 1, 1910,	-	-	\$400 90

Library Fund.

Five bonds Lake Shore & Michigan Southern Railroad Company 4s, at \$93½,	\$4,675 00	\$5,000 00	\$200 00
Five bonds New York Central & Hudson River Railroad Company 4s, at \$93½,	4,675 00	5,000 00	200 00
Two shares New York Central & Hudson River Railroad Company stock, at \$112,	224 00	200 00	11 50
Sale of rights of New York Central & Hudson River Rail- road Company stock,	-	-	12 90
Amherst Savings Bank, deposit,	167 77	167 77	6 68
	\$9,741 77	\$10,367 77	\$431 08
Transferred to college library account,	-	-	431 08

SPECIAL FUNDS.

Endowed Labor Fund (the Gift of a Friend of the College).

	Market Value Dec. 1, 1910.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at \$93½,	\$1,870 00	\$2,000 00	\$80 00
Two bonds Lake Shore & Michigan Southern Railroad Company 4s, at \$93½,	1,870 00	2,000 00	80 00
One bond New York Central Railroad debenture 4s, . . .	935 00	1,000 00	40 00
Amherst Savings Bank, deposit,	143 39	143 39	5 72
	\$4,818 39	\$5,143 39	\$205 72
Gift of a friend, Hon. Lucius Tuttle,	-	-	100 00
Unexpended balance Dec. 1, 1909,	-	-	680 67
Cash on hand Dec. 1, 1910,	-	-	\$986 39

SPECIAL FUNDS—*Continued.**Whiting Street Scholarship Fund.*

	Market Value Dec. 1, 1910.	Par Value.	Income.
One bond New York Central debenture 4s,	\$935 00	\$1,000 00	\$40 00
Amherst Savings Bank, deposit,	271 64	271 64	10 84
	\$1,206 64	\$1,271 64	\$50 84
Unexpended balance Dec. 1, 1909,	—	—	36 79
			\$87 63
Disbursements for scholarships for fiscal year ending Nov. 30, 1910,	—	—	30 00
Cash on hand Dec. 1, 1910,	—	—	\$57 63

Hills Fund.

Northampton Institution for Savings, deposit,	\$1,180 00	\$1,180 00	\$44 66
One bond American Telephone and Telegraph Company 4s,	910 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 4s,	935 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad Company 3½s,	840 00	1,000 00	35 00
One bond New York Central & Hudson River Railroad gold note, 5 per cent.,*	—	1,000 00	25 00
One bond Western Electric Company 5s,	1,000 00	1,000 00	25 00
One bond Metropolitan Street Railway, Kansas City, 5 per cent.,	980 00	1,000 00	50 00
Three bonds Pacific Telephone and Telegraph Company 5s, at \$98,	2,940 00	3,000 00	150 00
Exchange on Metropolitan Street Railway bond,	—	—	20 00
Boston & Albany Railroad stocks, at \$224,	812 00	362 00	31 68
Amherst Savings Bank, deposit,	72 75	72 75	2 88
	\$9,669 75	\$10,614 75	\$464 22
*On Feb. 1, 1910:— One New York Central & Hudson River gold note was sold for \$1,000 00	—	—1,000 00	—
One bond Western Electric Company 5s was purchased for 998 33	—	—	1 67
Unexpended balance Dec. 1, 1909,	—	—	379 70
	\$9,669 75	\$9,614 75	\$845 59
Disbursements by horticultural and botanical depart- ments for fiscal year ending Nov. 30, 1910,	—	—	227 13
Cash on hand Dec. 1, 1910,	—	—	\$618 46

Mary Robinson Fund.

Northampton Institution for Savings, deposit,	\$820 00	\$820 00	\$31 04
Boston & Albany Railroad stock, at \$224,	84 00	38 00	3 32
	\$904 00	\$858 00	\$34 36
Unexpended balance Dec. 1, 1909,	—	—	21 17
Cash on hand Dec. 1, 1910,	—	—	\$55 53

SPECIAL FUNDS—*Concluded.**Grinnell Prize Fund.*

	Market Value Dec. 1, 1910.	Par Value.	Income.
Ten shares New York Central & Hudson River Railroad stock,	\$1,120 00	\$1,000 00	\$57 50
Sale of rights of New York Central & Hudson River Railroad Company's stock,	—	—	64 50
Unexpended balance Dec. 1, 1909,	—	—	\$122 00 121 24
Disbursements for prizes,	—	—	\$243 24 50 00
Cash on hand Dec. 1, 1910,	—	—	\$193 24

Gassett Scholarship Fund.

One bond New York Central debenture 4s, at \$93½,	\$935 00	\$1,000 00	\$40 00
Amherst Savings Bank, deposit,	11 64	11 64	44
Unexpended balance Dec. 1, 1909,	\$946 64 —	\$1,011 64 —	\$40 44 33 43
Disbursements for scholarships for fiscal year ending Nov. 30, 1910,	—	—	\$73 87 37 50
Cash on hand Dec. 1, 1910,	—	—	\$36 37

Massachusetts Agricultural College (Investment).

One share New York Central & Hudson River Railroad stock,	\$112 00	\$100 00	\$5 75
Sale of rights of New York Central & Hudson River Railroad Company's stock,	—	—	6 45
Unexpended balance Dec. 1, 1909,	—	—	\$12 20 38 00
Cash on hand Dec. 1, 1910,	—	—	\$50 20

Danforth Keyes Bangs Fund.

Two bonds Pacific Telephone and Telegraph Company 5s, at \$98,	\$1,960 00	\$2,000 00	\$100 00
Two bonds American Telephone and Telegraph Company 4s, at \$91,	1,820 00	2,000 00	80 00
Two bonds Union Electric Light and Power Company 5s, at \$99,	1,980 00	2,000 00	100 00
Interest received from loan,	—	—	1 25
Unexpended balance Dec. 1, 1909,	\$5,760 00 —	\$6,000 00 —	\$281 25 234 04
Loan to students outstanding,	—	—	\$515 29 170 00
Cash on hand Dec. 1, 1910,	—	—	\$345 29

John C. Cutter Fund.

	Market Value Dec. 1, 1910.	Par Value.	Income.
One bond Pacific Telephone and Telegraph Company 5s, at \$98,*	\$980 00	\$1,000 00	\$25 00
*Amount of John C. Cutter fund, . . . \$1,000 00	-	-	-
One Pacific Telephone and Telegraph bond, . . . 996 67	-	-	3 33
Cash on hand Dec. 1, 1910,	-	-	\$28 33

SUMMARY OF BALANCES ON HAND OF THE INCOME FROM FUNDS HELD IN
TRUST BY THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Burnham emergency fund,	\$400 90
Endowed labor fund,	986 39
Whiting Street scholarship fund,	57 63
Hills fund,	618 46
Mary Robinson fund,	55 53
Grinnell prize fund,	193 24
Gassett scholarship fund,	36 37
Massachusetts Agricultural College investment,	50 20
Danforth Keyes Bangs fund,	345 29
John C. Cutter fund,	28 33
	<hr/>
	\$2,772 34

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the treasurer, Fred C. Kenney, for the year ending Nov. 30, 1910. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

AMHERST, Dec. 12, 1910.

HISTORY OF SPECIAL FUNDS.

Burnham emergency fund:—

A bequest from T. O. H. P. Burnham of Boston, made without any conditions. The trustees of the college have voted that the fund be kept intact, and that the income from it be used for the college for such purposes as they believe to be for its best interest, \$5,000 00

Library fund:—

The library of the college at the present time contains about 30,000 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave \$2,000; Jan. 1, 1894, Charles L. Flint gave \$1,000; in 1887 Elizur Smith of Lee, Mass., gave \$1,215. These were the largest bequests, and amount now to . . . 10,000 00

Endowed labor fund:—

Gift of a friend of the college in 1901, income of which is to be used for the assistance of needy and deserving students, \$5,000 00

Whiting Street scholarship:—

Gift of Whiting Street of Northampton, for no special purpose, but to be invested and the income used. This fund is now used exclusively for scholarship, . . . 1,000 00

Hills fund:—

Gift of Leonard M. and Henry F. Hills, in 1867, to establish and maintain a botanic garden, . . . 10,000 00

Mary Robinson fund:—

Gift of Miss Mary Robinson of Medfield, in 1874, for scholarship, 1,000 00

Grinnell prize fund:—

Gift of Hon. Wm. Claflin, to be known as the Grinnell agricultural prize, to be given to the two members of the graduating class who may pass the best oral and written examination in theory and practice of agriculture, given in honor of George B. Grinnell of New York, 1,000 00

Gassett scholarship fund:—

Gift of Henry Gassett of Boston, the income to be used for scholarship, 1,000 00

Massachusetts Agricultural College investment fund:—

Investment made by vote of trustees, in 1893; to purchase one share New York Central & Hudson River Railroad stock. The income from this fund has been allowed to accumulate, 100 00

Danforth Keyes Bangs fund:—

Gift on account of the Louisa Baker estate, April 14, 1909, the income thereof to be used annually in aiding poor, industrious and deserving students to obtain an education in said college, 6,000 00

John C. Cutter fund:—

Gift of Dr. John C. Cutter, an alumnus of the college, who died in August, 1909, to be invested by the trustees, and the income to be annually used for the purchase of books on hygiene, 1,000 00

\$41,100 00

PRIZES.

Special prize, for best work done in entomology by undergraduates. This prize is given by the alumni entomologists,	\$30 00
Special prize, in honor of J. W. D. French, given by the Bay State Agricultural Society, for the best essay on forestry from the senior class,	25 00
Special prize, given by the Western Alumni Association to that member of the sophomore class who during his first two years has shown the greatest improvement in scholarship, character and example,	25 00
	<hr/>
	\$80 00

FRED C. KENNEY,

Treasurer.

THE M. A. C. BULLETIN

AMHERST, MASS.

Vol. III. No. 2.

For February, 1911.

Published Six Times a Year by the College.

Jan., Feb., Mar., May, Sept., Oct.

ENTERED AS SECOND-CLASS MAIL MATTER AT THE POST OFFICE, AMHERST, MASS.

Public Document

No. 31

CATALOGUE

OF THE

MASSACHUSETTS

AGRICULTURAL COLLEGE,

1910-1911.

FORTY-EIGHTH ANNUAL REPORT.

PART II.



BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1911.



Without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. — *Act of Congress, July 2, 1862.*

MASSACHUSETTS AGRICULTURAL COLLEGE, AMHERST.

CATALOGUE, 1910-1911.



BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1911.

APPROVED BY
THE STATE BOARD OF PUBLICATION.

Vacations and holidays are indicated by light-faced type.

1910.							1911.							1912.						
JULY.							JANUARY.							JULY.						
S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S
..	..	..	..	..	1	2	1	2	3	4	5	6	7	..	..	..	..	..	1	2
3	4	5	6	7	8	9	8	9	10	11	12	13	14	2	3	4	5	6	7	8
10	11	12	13	14	15	16	15	16	17	18	19	20	21	9	10	11	12	13	14	15
17	18	19	20	21	22	23	22	23	24	25	26	27	28	16	17	18	19	20	21	22
24	25	26	27	28	29	30	29	30	31	..	..	..	..	23	24	25	26	27	28	29
31	..	..	..	..	..	..	..	..	..	..	..	..	..	30	31	..	..	..	..	..
AUGUST.							FEBRUARY.							AUGUST.						
S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S
..	1	2	3	4	5	6	..	..	1	2	3	4	..	..	1	2	3	4	5	6
7	8	9	10	11	12	13	5	6	7	8	9	10	11	6	7	8	9	10	11	12
14	15	16	17	18	19	20	12	13	14	15	16	17	18	13	14	15	16	17	18	19
21	22	23	24	25	26	27	19	20	21	22	23	24	25	20	21	22	23	24	25	26
28	29	30	31	..	..	..	26	27	28	..	..	..	..	27	28	29	30	31	..	..
..
SEPTEMBER.							MARCH.							SEPTEMBER.						
S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S
..	..	..	..	1	2	3	..	..	1	2	3	4	..	..	..	1	2	3	4	5
4	5	6	7	8	9	10	5	6	7	8	9	10	11	3	4	5	6	7	8	9
11	12	13	14	15	16	17	12	13	14	15	16	17	18	10	11	12	13	14	15	16
18	19	20	21	22	23	24	19	20	21	22	23	24	25	17	18	19	20	21	22	23
25	26	27	28	29	30	..	26	27	28	29	30	31	..	24	25	26	27	28	29	30
..
OCTOBER.							APRIL.							OCTOBER.						
S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S
..	..	..	..	..	1	..	..	..	..	..	1	2	3	1	2	3	4	5	6	7
2	3	4	5	6	7	8	2	3	4	5	6	7	8	8	9	10	11	12	13	14
9	10	11	12	13	14	15	9	10	11	12	13	14	15	15	16	17	18	19	20	21
16	17	18	19	20	21	22	16	17	18	19	20	21	22	22	23	24	25	26	27	28
23	24	25	26	27	28	29	23	24	25	26	27	28	29	29	30	31	..	..	..	..
30	31	..	..	..	..	..	30	..	..	..	..	..	..	..	..	..	..	..	..	..
NOVEMBER.							MAY.							NOVEMBER.						
S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S
..	..	1	2	3	4	5	..	1	2	3	4	5	6	..	..	1	2	3	4	5
6	7	8	9	10	11	12	7	8	9	10	11	12	13	5	6	7	8	9	10	11
13	14	15	16	17	18	19	14	15	16	17	18	19	20	12	13	14	15	16	17	18
20	21	22	23	24	25	26	21	22	23	24	25	26	27	19	20	21	22	23	24	25
27	28	29	30	..	..	..	28	29	30	31	..	..	..	26	27	28	29	30	31	..
..
DECEMBER.							JUNE.							DECEMBER.						
S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S
..	..	..	..	1	2	3	..	..	..	1	2	3	..	..	..	..	1	2	3	4
4	5	6	7	8	9	10	4	5	6	7	8	9	10	3	4	5	6	7	8	9
11	12	13	14	15	16	17	11	12	13	14	15	16	17	10	11	12	13	14	15	16
18	19	20	21	22	23	24	18	19	20	21	22	23	24	17	18	19	20	21	22	23
25	26	27	28	29	30	31	25	26	27	28	29	30	..	24	25	26	27	28	29	30
..	..	..	..	..	..	..	..	..	..	..	..	..	..	31	..	..	..	..	..	..

THE MASSACHUSETTS
AGRICULTURAL COLLEGE.

Beginning with this issue, the catalogue represents a statement of the courses of study, and the status of the college, for the current college year, unless the contrary is indicated in the text. Announcement of changes affecting the work of the following year will be made later.

CALENDAR.

1911-1912.

REGULAR COURSES.

1911.

January 2, Monday, 1 P.M., . . .	Winter recess ends; chapel.
January 30, Monday, . . .	Semester examinations begin.
February 6, Monday, 1 P.M., . . .	Second semester begins; chapel.
February 22, Wednesday, . . .	Half holiday, Washington's Birth-day.
March 24, Friday, 6 P.M., . . .	Spring recess begins.
April 3, Monday, 1 P.M., . . .	Spring recess ends; chapel.
April 19, Wednesday, . . .	Half holiday, Patriot's Day.
May 30, Tuesday, . . .	Holiday, Memorial Day.
June 5, Monday, . . .	Senior examinations begin.
June 12, Monday, . . .	Non-senior examinations begin.
June 17-21, Saturday-Wednesday, . . .	Commencement.
June 21-24, Wednesday-Saturday, . . .	Entrance examinations.

Summer Vacation.

September 11-13, Monday-Wednesday, . . .	Condition examinations.
September 11-14, Monday-Thursday, . . .	Entrance examinations.
September 13, Wednesday, 1.30 P.M., . . .	First semester begins; assembly.
October 12, Thursday, . . .	Half holiday, Columbus Day.
November 29-December 4, Wednesday, 1 P.M.-Monday, 1 P.M., chapel, . . .	Thanksgiving recess.
December 15, Friday, 6 P.M., . . .	Winter recess begins.

1912.

January 1, Monday, 1 P.M., . . .	Winter recess ends; chapel.
January 29, Monday, . . .	Semester examinations begin.
February 5, Monday, 1 P.M., . . .	Second semester begins; chapel.
February 22, Thursday, . . .	Half holiday, Washington's Birth-day.
March 29, Friday, 6 P.M., . . .	Spring recess begins.
April 8, Monday, 1 P.M., . . .	Spring recess ends; chapel.
April 19, Friday, . . .	Half holiday, Patriot's Day.
May 30, Thursday, . . .	Holiday, Memorial Day.
June 3, Monday, . . .	Senior examinations begin.
June 10, Monday, . . .	Non-senior examinations begin.
June 15-19, Saturday-Wednesday, . . .	Commencement.
June 19-22, Wednesday-Saturday, . . .	Entrance examinations.

SHORT COURSES, 1911.

- Ten weeks' general course, January 3-March 10.
- Two weeks' course in poultry management, February 26-March 10.
- Farmers' week, March 13-March 17.
- Beekeeping course, May 24-June 7.
- Summer school begins July 3.



ERRATA AND ADDENDA.

Page 15. — After "Guy Chester Crampton," insert "J. C. Graham, B.Sc., Associate Professor of Poultry Husbandry, beginning Feb. 15, 1911."

Page 16. — "Marcus T. Smulyan" (not Smulyou); the name should appear under "Graduate Assistants."

Page 17. — Under "Additional Instructors," omit name of "J. W. Wellman."

Pages 41, 42. — The tables state inaccurately the credits in freshman, sophomore and junior physical education and military science. These credits should be:—

Freshman Year. — Semester 1: Drill, 1 hour. Semester 2: Drill, 1 hour; Physical Education, 1 hour.

Sophomore and Junior Year (Each). — Semester 1: Drill, 1 hour; Tactics, 1 hour. Semester 2: Drill, 1 hour; Tactics, 1 hour; Physical Education, 1 hour.

The footings of the credit-hour columns should therefore read:—

Freshman Year. — Semester 1, 18 or 19.

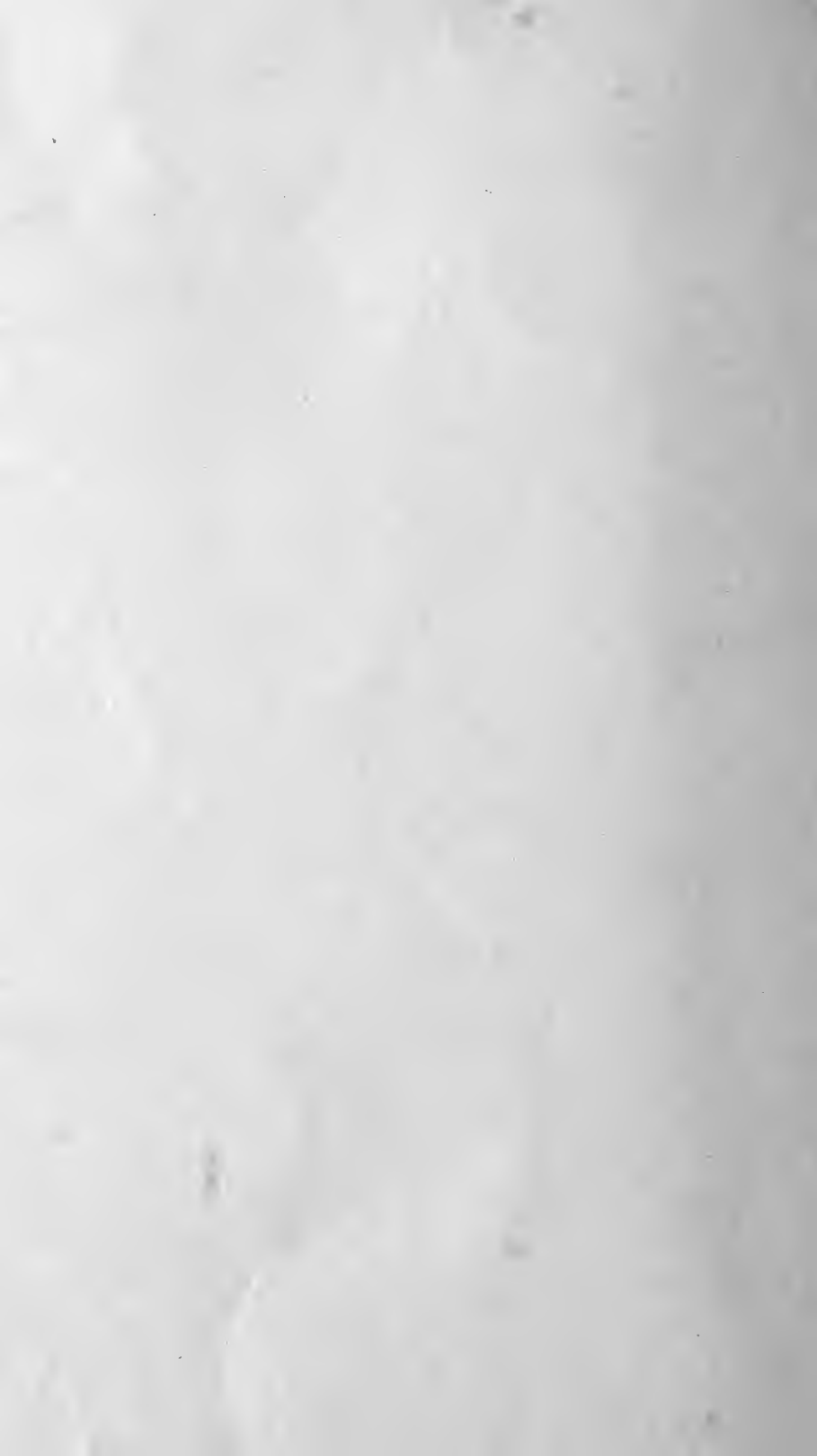
Sophomore Year. — Semester 2, 20 or 18.

Page 57. — *Department of Entomology.* In name-list, after "Professor Fernald," insert "Associate Professor Crampton."

Page 64, footnote 2. — Add "Stephen Hamblin (second semester)."

Page 79. — *Department of Rural Social Science.* To name-list add "Mr. Holcomb."

Page 82. — *Department of Veterinary Science.* To name-list add "Mr. Larsen."



MASSACHUSETTS AGRICULTURAL COLLEGE.

HISTORY. — The Massachusetts Agricultural College was among the colleges organized under the national land grant act of 1862. This act gave public lands to the several States and Territories for the establishment of colleges for the benefit of agriculture and the mechanic arts; it was framed by the late Senator Justin Smith Morrill of Vermont. For our own college, liberal appropriations are also made by the Legislature of Massachusetts.

The college was incorporated in 1863, and on the 2d of October, 1867, was formally opened to an entering class of 33. In January, 1875, an arrangement was made with the authorities of Boston University under which the college, without losing its independence, became the school of agriculture of the university. Under this arrangement, graduates of the Massachusetts Agricultural College may, upon certain conditions, receive the diploma in science awarded to graduates of the university. In 1882 the State experiment station was located at the college. It has since been incorporated with the college.

COURSES. — The college offers a free education to any American student who may fulfill the requirements of admission. Women are admitted on the same standing as men. Foreign students pay a tuition fee. The four-years course leads to the degree of bachelor of science, and graduate courses are given leading to the degrees of master of science and of doctor of philosophy. Winter courses of ten weeks are offered, and, upon announcement, special courses. There is also a summer school of agriculture, designed chiefly for persons desiring to teach agriculture in the elementary and high schools.

PURPOSE OF THE COLLEGE. — The chief purpose of the college is to prepare men and women for the agricultural vocations. In this statement, the term "agricultural" is used in the broadest sense. Courses are offered which give efficiency in various practical pursuits, such as general farming, dairying, the management of estates, fruit growing, glass farming, landscape gardening, forestry and arboriculture. Students also qualify for positions in institutions designed for investigation in the many sciences underlying

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the great agricultural industry, for teaching in agricultural colleges and high schools, and for business occupations having connection with the farm and needing expert service.

Though the agricultural vocations are thus the chief concern of the college, students also find the course one that fits them admirably for pursuits in which the sciences — particularly chemistry, physics, mathematics and engineering — are an essential preparation. Still other students find the course a splendid general education, without regard to future occupation. The course is well balanced; each student is required to study English, a modern foreign language, literature, political science and history.

LOCATION AND EQUIPMENT. — Situated in the beautiful town of Amherst, the college has an inspiring outlook. The campus is especially attractive. The grounds comprise more than 475 acres, lying about a mile north of the village center. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst, 97 miles west of Boston, is on the Central Vermont Railroad and the Central Massachusetts division of the Boston & Maine Railroad. Electric car lines connect the village with Northampton, Holyoke, Springfield and other cities. The town library is open to students, in addition to the college library, as are also good courses of lectures and concerts in the village, supplementing the various interests of college life.

THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established as a department of the college. It was supported by the general government. For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the general government. In 1906 the general government largely increased its support of experiment stations, on condition, however, that the money thus provided should be used only for research. The station now receives about two-fifths of its support from the State.

The station is under the direct supervision of the Board of Trustees. The chief officer is the director, who is responsible to the president and to the committee of the Board. The station is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of the station departments are heads of corresponding departments in the college. The work of the station takes three directions; namely, control work, extension work and investigation. The station publishes numerous bulletins and two annual reports, one scientific, the other for practical farmers and for general distribution. These publications, conveying information as to results of experiments, are free, and circulate extensively, the mailing list containing some 20,000 addresses.

THE CORPORATION.

MEMBERS OF THE CORPORATION.

	TERM EXPIRES
DAVIS R. DEWEY of Cambridge,	1912
M. FAYETTE DICKINSON of Brookline,	1912
WILLIAM H. BOWKER of Concord,	1913
GEORGE H. ELLIS of West Newton,	1913
CHARLES E. WARD of Buckland,	1914
ELMER D. HOWE of Marlborough,	1914
NATHANIEL I. BOWDITCH of Framingham,	1915
WILLIAM WHEELER of Concord,	1915
ARTHUR G. POLLARD of Lowell,	1916
CHARLES A. GLEASON of New Braintree,	1916
FRANK GERRETT of Greenfield,	1917
HAROLD L. FROST of Arlington,	1917
CHARLES H. PRESTON of Danvers,	1918
FRANK A. HOSMER of Amherst,	1918

MEMBERS EX OFFICIO.

His Excellency Governor EUGENE N. FOSS, *President of the Corporation.*
 KENYON L. BUTTERFIELD, *President of the College.*
 DAVID SNEDDEN, *State Commissioner of Education.*
 J. LEWIS ELLSWORTH, *Secretary of the State Board of Agriculture.*

OFFICERS OF THE CORPORATION.

His Excellency Governor EUGENE N. FOSS of Boston, *President.*
 CHARLES A. GLEASON of Springfield, *Vice-President.*
 J. LEWIS ELLSWORTH of Worcester, *Secretary.*
 FRED C. KENNEY of Amherst, *Treasurer.*
 CHARLES A. GLEASON of Springfield, *Auditor.*

STANDING COMMITTEES OF THE CORPORATION.¹

Committee on Finance.

CHARLES A. GLEASON, <i>Chairman.</i>	ARTHUR G. POLLARD.
GEORGE H. ELLIS.	CHARLES E. WARD.
NATHANIEL I. BOWDITCH.	FRANK A. HOSMER.

¹ The president of the college is ex officio member and secretary of standing committees. The director of the experiment station is a member of the committee on experiment department, without vote.

*Committee on Course of Study and Faculty.*WILLIAM WHEELER, *Chairman.*

WILLIAM H. BOWKER.

M. FAYETTE DICKINSON.

DAVID SNEDDEN.

ELMER D. HOWE.

DAVIS R. DEWEY.

FRANK A. HOSMER.

*Committee on Farm.*GEORGE H. ELLIS, *Chairman.*

FRANK GERRETT.

CHARLES A. GLEASON.

NATHANIEL I. BOWDITCH.

*Committee on Horticulture.*J. LEWIS ELLSWORTH, *Chairman.*

DAVIS R. DEWEY.

ELMER D. HOWE.

HAROLD L. FROST.

*Committee on Experiment Department.*CHARLES H. PRESTON, *Chairman.*

J. LEWIS ELLSWORTH.

ARTHUR G. POLLARD.

CHARLES E. WARD.

HAROLD L. FROST.

*Committee on Buildings and Arrangement of Grounds.*M. FAYETTE DICKINSON, *Chairman.*

WILLIAM WHEELER.

FRANK GERRETT.

WILLIAM H. BOWKER.

CHARLES H. PRESTON.

Examining Committee of Overseers.

JOHN BURSLEY of West Barnstable.

ISAAC DAMON of Wayland.

N. B. TURNER of Great Barrington.

FRANK P. NEWKIRK of Easthampton.

WILLIAM E. PATRICK of Warren.

OFFICERS OF THE INSTITUTION.

THE FACULTY.

[The names of the faculty are arranged in groups according to rank. Within these groups the order depends upon seniority of service in the college, not upon seniority of appointment to the position now held.]

KENYON L. BUTTERFIELD, A.M., LL.D.,	President's House.
President of the College and Professor of Rural Sociology.	
GEORGE F. MILLS, ¹ M.A.,	46 Amity Street.
Dean of the College, Head of the Division of the Humanities and Professor of Languages and Literature.	
CHARLES H. FERNALD, Ph.D.,	3 Hallock Street.
Honorary Director of the Graduate School.	
WILLIAM P. BROOKS, Ph.D.,	28 Northampton Road.
Director of the Experiment Station and Lecturer on Soil Fertility.	
WILLIAM D. HURD, M.Agr.,	82 Pleasant Street.
Director of Extension Work.	
FRANK A. WAUGH, M.Sc.,	Massachusetts Agricultural College.
Head of the Division of Horticulture and Professor of Landscape Gardening.	
JAMES A. FOORD, M.Sc.,	Nutting Avenue.
Head of the Division of Agriculture and Professor of Farm Administration.	
CHARLES WELLINGTON, Ph.D.,	34 Amity Street.
Professor of General and Agricultural Chemistry.	
JAMES B. PAIGE, B.Sc., D.V.S.,	42 Lincoln Avenue.
Professor of Veterinary Science, and Acting Dean.	
GEORGE E. STONE, Ph.D.,	Mount Pleasant.
Professor of Botany.	
JOHN E. OSTRANDER, A.M., C.E.,	33 North Prospect Street.
Professor of Mathematics and Civil Engineering.	
HENRY T. FERNALD, Ph.D.,	44 Amity Street.
Acting Director of the Graduate School and Professor of Entomology.	
GEORGE C. MARTIN, C.E., Captain, 18th U. S. Infantry,	35 North Prospect Street.
Professor of Military Science and Tactics.	
EDWARD A. WHITE, B.Sc.,	Mount Pleasant.
Professor of Floriculture.	
WILLIAM R. HART, A.M.,	97 Pleasant Street.
Professor of Agricultural Education.	
FRED C. SEARS, M.Sc.,	Mount Pleasant.
Professor of Pomology.	

¹ Absent on leave.

FRED C. KENNEY,	Mount Pleasant.
Treasurer of the College.	
PHILIP B. HASBROUCK, B.Sc.,	130 Pleasant Street.
Registrar of the College, Associate Professor of Mathematics and Adjunct Professor of Physics.	
ROBERT WILSON NEAL, A.M.,	7 Woodside Avenue.
Associate Professor of English.	
JOSEPH S. CHAMBERLAIN, Ph.D.,	16 North Prospect Street.
Associate Professor of Chemistry.	
WILLIAM P. B. LOCKWOOD, B.Sc.Agr.,	5 East Pleasant Street.
Associate Professor of Dairying.	
FRANK F. MOON, B.A., M.F.,	6 Allen Street.
Associate Professor of Forestry.	
JOHN ALLEN MCLEAN, ¹ B.A., B.S., A.,	— — — — —
Associate Professor of Animal Husbandry.	
GUY CHESTER CRAMPTON, ² Ph.D.,	— — — — —
Associate Professor of Entomology.	
S. FRANCIS HOWARD, M.Sc.,	10 Allen Street.
Assistant Professor of Chemistry.	
A. VINCENT OSMUN, M.Sc.,	North Amherst, Mass.
Assistant Professor of Botany.	
SIDNEY B. HASKELL, B.Sc.,	5 Fearing Street.
Assistant Professor of Agronomy.	
CLARENCE E. GORDON, A.M.,	North Amherst, Mass.
Assistant Professor of Zoölogy and Geology.	
PERCY L. REYNOLDS, M.D.,	17 Fearing Street.
Assistant Professor of Physical Education and Hygiene.	
FLOYD B. JENKS, B.Sc.Agr.,	North Adams, Mass.
Assistant Professor of Agricultural Education.	
ALEXANDER E. CANCE, Ph.D.,	9 Fearing Street.
Assistant Professor of Agricultural Economics.	
FREDERICK B. MCKAY, A.B.,	12 Cottage Street.
Assistant Professor of English and Public Speaking.	
ELMER K. EYERLY, A.M.,	North Amherst, Mass.
Assistant Professor of Political Science and Lecturer in Rural Sociology.	
BURTON N. GATES, Ph.D.,	42 Lincoln Avenue.
Assistant Professor of Beekeeping.	
GEORGE N. HOLCOMB, A.B., S.T.B.,	South Amherst, Mass.
Lecturer in History.	
FRANK W. RANE,	Boston, Mass.
Lecturer in Forestry.	
RAY L. GRIBBEN, ³ B.Sc.Agr.,	66 Pleasant Street.
Instructor in Animal Husbandry.	
EDGAR L. ASHLEY, A.M.,	Prospect House.
Instructor in German.	
ANDERSON A. MACKIMMIE, A.B.,	Nutting Avenue.
Instructor in French and Spanish, Assistant to the Dean.	
C. ROBERT DUNCAN, B.Sc.,	46 Pleasant Street.
Instructor in Mathematics and Physics.	

¹ Beginning with second semester.² Beginning April 1, 1911.³ Resigned Jan. 20, 1911.

CHARLES R. GREEN, B.Agr.,	Mount Pleasant.
Librarian.	
CHARLES S. HELLER,	1 Allen Street.
Instructor in Market Gardening.	
ALVAH J. NORMAN, B.Sc.,	Phillips Street.
Instructor in Pomology.	
CHARLES J. ROBINSON, B.Sc.,	Lincoln Block.
Instructor in Dairying and Animal Husbandry.	
JOHN NOYES, B.Sc.,	Wilder Hall.
Assistant in Landscape Gardening.	
W. A. TURNER, Ph.B.,	34 Amity Street.
Assistant in Chemistry.	
ALFRED LARSEN, B.Sc.,	— —
Assistant in Bacteriology.	
MARCUS T. SMULYOU,	— —
Graduate Assistant in Botany.	
Miss HELENA GOESSMANN,	Amity Street.
Assistant in English.	

GRADUATE ASSISTANTS.

JOHN N. SUMMERS, B.Sc.,	66 Pleasant Street.
Assistant in Entomology.	
LEONARD S. McLAINE, B.Sc.,	84 Pleasant Street.
Assistant in Zoölogy.	

OTHER COLLEGE OFFICERS.

EDWIN H. FORRISTALL, M.Sc.,	Massachusetts Agricultural College.
Farm Superintendent.	
RALPH J. WATTS, B.Sc.,	9 Fearing Street.
Secretary to the President.	
CHARLES H. WHITE, B.Sc.,	North Amherst, Mass.
Field Agent.	
NEWTON WALLACE,	6 Phillips Street.
Electrician.	
CLARENCE A. JEWETT,	112 Pleasant Street.
Superintendent of Buildings.	
JAMES WHITING,	Hallock Street.
Foreman, Department of Floriculture.	
WILLIAM CHESLEY,	Draper Hall.
Steward, Dining Hall.	
Miss MARY E. CALDWELL,	Draper Hall.
Bookkeeper.	
Miss CLARA L. STUART, ¹	— —
Correspondence Clerk.	
Miss HENRIETTA WEBSTER,	Draper Hall.
Clerk, Treasurer's Office.	
Miss GERTRUDE E. WARNER, ²	— —
Stenographer, Division of Agriculture.	
Miss RUTH G. SMITH,	North Amherst, Mass.
Clerk to the Dean and Registrar.	

¹ Absent after Feb. 1, 1911.² Resigned December, 1910.

Miss HELEN GRANGER,	Draper Hall.
Stenographer, Division of Horticulture.	
Miss DOROTHY MUDGE,	North Amherst, Mass.
Clerk, Treasurer's Office.	
Miss MABEL R. CASE,	Draper Hall.
Clerk, Division of Short Courses and Extension Work.	
Miss STELLA H. WEBB,	Draper Hall.
Correspondence Clerk, President's Office.	
Miss LILLIAN M. GELINAS,	Draper Hall.
Clerk, President's Office.	
Miss ALICE GILBERT,	Draper Hall.
Stenographer, Division of Agriculture.	

ADDITIONAL INSTRUCTORS FOR THE WINTER SCHOOL, 1911.

F. E. VAN HORN, Instructor in Butter Making.

J. W. WELLMAN, Instructor in the Use of Separators.

OFFICERS OF SHORT COURSE AND EXTENSION WORK.

WILLIAM D. HURD, M.Agr.,	82 Pleasant Street.
Director.	
CHARLES H. WHITE, B.Sc.,	North Amherst, Mass.
Field Agent.	
ALVAH J. NORMAN, B.Sc.,	Phillips Street.
Horticulture.	
CHARLES J. ROBINSON, B.Sc.,	Lincoln Block.
Dairying and Animal Husbandry.	
Miss MABEL R. CASE,	Draper Hall.
Clerk to the Director of Short Courses.	

OFFICERS OF THE EXPERIMENT STATION.

WILLIAM P. BROOKS, Ph.D.,	28 Northampton Road.
Director.	
JOSEPH B. LINDSEY, Ph.D.,	47 Lincoln Avenue.
Vice-Director.	
FRED C. KENNEY,	Mount Pleasant.
Treasurer.	
CHARLES R. GREEN, B.Agr.,	Mount Pleasant.
Librarian.	

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

JOSEPH B. LINDSEY, Ph.D.,	47 Lincoln Avenue.
Chemist.	
EDWARD B. HOLLAND, M.Sc.,	28 North Prospect Street.
Associate Chemist, in charge of Research Division.	
FRED W. MORSE, Ph.D.,	44 Pleasant Street.
Research Chemist.	
HENRI D. HASKINS, B.Sc.,	87 Pleasant Street.
In charge of Fertilizer Division.	
PHILIP H. SMITH, B.Sc.,	102 Main Street.
In charge of Feed and Dairy Division.	
LEWELL S. WALKER, B.Sc.,	19 Phillips Street.
Assistant.	
JAMES C. REED, B.Sc.,	Nutting Avenue.
Assistant.	
JOSEPH F. MERRILL, B.Sc.,	North Prospect Street.
Assistant.	
CLEMENT L. PERKINS, B.Sc.,	32 North Prospect Street.
Assistant.	
JOSEPH P. HOWARD,	North Amherst, Mass.
Collector.	
HARRY J. ALLEN,	Amherst, Mass.
Assistant.	
JAMES R. ALCOCK,	North Amherst, Mass.
Assistant in Animal Nutrition.	

DEPARTMENT OF AGRICULTURE.

WILLIAM P. BROOKS, Ph.D.,	Massachusetts Agricultural College.
Agriculturist.	
H. J. FRANKLIN, Ph.D.,	Wareham, Mass.
In charge of Cranberry Investigation.	

ERWIN S. FULTON, B.Sc., North Amherst, Mass.
 First Assistant Agriculturist.
 EDWIN F. GASKILL, B.Sc., North Amherst, Mass.
 Second Assistant Agriculturist.

DEPARTMENT OF HORTICULTURE.

FRANK A. WAUGH, M.Sc., Massachusetts Agricultural College.
 Horticulturist.
 FRED C. SEARS, M.Sc., Mount Pleasant.
 Pomologist.
 JACOB K. SHAW, M.Sc., 1 Allen Street.
 Assistant Horticulturist.
 DAVID W. ANDERSON, B.Sc., 32 North Prospect Street.
 Graduate Assistant.

DEPARTMENT OF BOTANY AND VEGETABLE PATHOLOGY.

GEORGE E. STONE, Ph.D., Mount Pleasant.
 Botanist and Vegetable Pathologist.
 GEORGE H. CHAPMAN, M.Sc., 13 Fearing Street.
 Assistant Botanist.
 SUMNER C. BROOKS, B.Sc., 28 Northampton Road.
 Assistant Botanist.

DEPARTMENT OF ENTOMOLOGY.

HENRY T. FERNALD, Ph.D., 44 Amity Street.
 Entomologist.
 BURTON N. GATES, Ph.D., 42 Lincoln Avenue.
 Apiarist.
 ARTHUR I. BOURNE, B.A., 66 North Pleasant Street.
 Assistant in Entomology.

DEPARTMENT OF VETERINARY SCIENCE.

JAMES B. PAIGE, B.Sc., D.V.S., 42 Lincoln Avenue.
 Veterinarian.

DEPARTMENT OF METEOROLOGY.

JOHN E. OSTRANDER, A.M., C.E., 35 North Prospect Street.
 Meteorologist.
 CHARLES M. DAMON, Massachusetts Agricultural College.
 Observer.

OTHER OFFICERS OF THE EXPERIMENT STATION.

Miss ROSE J. BROWN, Draper Hall.
 Secretary to the Director.
 Miss JESSIE V. CROCKER, Sunderland, Mass.
 Stenographer, Department of Botany and Vegetable Pathology.

- Miss HARRIET COBB, 35 North Pleasant Street.
Stenographer, Department of Plant and Animal Chemistry.
- Miss BRIDIE O'DONNELL, Hadley, Mass.
Stenographer, Department of Entomology.
- Miss ALICE M. HOWARD, North Amherst, Mass.
Stenographer, Department of Plant and Animal Chemistry.

COMMITTEES OF THE FACULTY.¹

1910-11.

SCHOLARSHIP.

The DEAN.

Professor HASBROUCK.

Professor WHITE.

Assistant Professor GORDON.

Mr. MACKIMMIE.

SCHEDULE.

Professor OSTRANDER.

Associate Professor LOCKWOOD.

Associate Professor NEAL.

STUDENT ACTIVITIES.

Professor HURD.

Captain MARTIN.

Associate Professor LOCKWOOD.

Assistant Professor EYERLY.

Assistant Professor MCKAY.

LIBRARY.

Professor STONE.

Professor BROOKS.

Professor WELLINGTON.

Assistant Professor CANCE.

GRADUATE SCHOOL.

Professor FERNALD.

Professor WELLINGTON.

Professor PAIGE.

Professor STONE.

Professor SEARS.

Assistant Professor GORDON.

¹ The President of the college is ex officio member of these standing committees.

COMMITTEE ON EMPLOYMENT.

Professor SEARS.

Mr. KENNEY.

Assistant Professor HASKELL.

ENTRANCE EXAMINATIONS AND ADMISSION.

The REGISTRAR.

Assistant Professor HOWARD.

Assistant Professor OSMUN.

Assistant Professor McKAY.

Mr. ASHLEY.

ATHLETICS.

Professor PAIGE.

Assistant Professor REYNOLDS.

Assistant Professor GORDON.

COURSE OF STUDY.

Professor HART.

Professor WAUGH.

Professor FOORD.

Professor OSTRANDER.

Associate Professor CHAMBERLAIN.

CATALOGUE AND OTHER PUBLICATIONS.

Associate Professor NEAL.

Assistant Professor EYERLY.

Assistant Professor CANCE.

UNCLASSIFIED STUDENTS.

Professor WHITE.

Associate Professor CHAMBERLAIN.

Associate Professor LOCKWOOD.

COMMENCEMENT.

Professor PAIGE.

Professor WELLINGTON.

Professor WHITE.

Captain MARTIN.

Mr. KENNEY.

Assistant Professor HOWARD.

ADVISORY COMMITTEE ON DISCIPLINE.

The DEAN.

The TREASURER.

The REGISTRAR.

The COMMANDANT.

THE COLLEGE.

ADMISSION.

A. APPLICATION FOR ADMISSION.

Correspondence about admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of good character. Such testimonials, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege on or before June 1 of the year in which examination is desired. Blanks for such application may be obtained by addressing the registrar of the college. If an applicant desires a free State scholarship, he must also present to the registrar a certificate of appointment from the State Senator of his district. Blanks for this purpose also may be obtained of the registrar. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. MODES OF ADMISSION.

Students are admitted to the freshman class either upon *certificate* or upon *examination*. No *diploma* from a secondary school will be considered.

CERTIFICATES. — The entrance requirements may be met by certification in any of the following ways: —

1. By presenting certificate from a school approved for such privilege by this college.
2. By presenting certificate from any school approved by the college entrance examination boards.
3. By presenting the customary credentials from the Board of Regents of the State of New York for any of the subjects of the entrance requirements.

Certificates must present at least three of the six required subjects for admission, and not less than seven of the necessary fourteen credits in all. Those subjects lacking on certificate (except for

the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

EXAMINATIONS. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.¹

Places of Examination. — Examinations for admission to the college are held as follows: —

In June of each year: in Amherst, in the building of the Department of Mathematics, Massachusetts Agricultural College; in Boston, in the College of Liberal Arts of Boston University, Boylston Street, corner of Exeter; in Worcester, in Horticultural Hall.

Schedule for Entrance Examinations, June 21–24, 1911. — The examinations in June will follow this schedule: —

First Day.

1 P.M. Registration.²

1.15–5 P.M. Latin (A and B).

Second Day.

8 A.M. Plane geometry.

10 A.M. Chemistry.

11.30 A.M. United States history and civics.

2 P.M. Algebra.

3.30 P.M. Physics.

4.30 P.M. Elective English.

¹ *Entrance with Condition in English.* — Under the rule permitting entrance conditions of not more than two units of the preparatory subjects, applicants may be admitted, upon examination, with a condition in English under these restrictions: (1) The parts of the preparatory study in English will be valued by the examiners approximately as follows in entrance units: (a) composition, etc., one and one-quarter units; (b) reading and study (including interpretation, three-quarters of a unit; see p. 28), one and three-quarters units; total, 3 units. (2) The applicant to show, upon examination, satisfactory preparation in work amounting to not less than two units.

The purpose of this provision is to avoid the possible injustice of excluding, without further trial, applicants who appear to be deficient in preparation in only one subject; and the examination will be so set as to permit the estimating of separate credits to carry out this purpose.

Attention is called to the standing rule of the uniform entrance requirement bodies concerning English as an admission subject; namely, that applicants whose work is seriously lacking in correct spelling, punctuation, grammar or other elementary essentials of good usage will be rejected.

Students so admitted, must, to remove the condition, pass an examination covering the regular 3-units requirement.

² Candidates who have no examination at the time set for registration may register at the time of their first examination should they so desire.

Third Day.

- 8 A.M. Required English.
 11 A.M. Solid geometry, agriculture.
 2 P.M. History, required and elective.
 5 P.M. Botany.

Fourth Day.

- 8 A.M. French, German, required and elective.
 1 P.M. Greek, and all one-half credit electives, except those already noted.

Schedule for Entrance Examinations in September.—In September, 1911, the examinations will be given September 11 to 14, inclusive, and will follow the order indicated for June, beginning September 11 at 1 P.M.

C. REQUIREMENTS FOR ADMISSION.

The requirements for admission are based on the completion of a four-years course in a high school or its equivalent, and are stated in terms of units. The term unit means the equivalent of five recitations a week for a school year. Neither more nor less credit will be given in any subject than is indicated in the table below. Fourteen units must be offered for admission, of which nine are required and five are elective.

(a) The following nine units are required:—

Language.

English,	3
French or German,	2

History and Civics.

United States history and civics,	$\frac{1}{2}$
History (elective),	1

- (a) Ancient history.
 (b) Medieval and modern history.
 (c) English history.
 (d) General history.

Mathematics.

Algebra, through progressions,	$1\frac{1}{2}$
Plane geometry,	1

(b) In addition to the requirements under (a), five units must be offered from the following-named elective subjects. Not more than four of those subjects in which the credit sought is one-half unit will be accepted.

Language.

English in addition to requirements,	1
French in addition to requirements,	2 or 1 ¹
German in addition to requirements,	2 or 1 ¹
Greek,	2 or 3
Latin,	2 or 3
Latin A, including Cæsar and Cicero, 2; Latin	
B, including Virgil and Prose Composition, 1.	

History.

In addition to requirements,	1 or 2
--	--------

Mathematics, and Other Sciences.

Solid geometry,	$\frac{1}{2}$
Trigonometry,	$\frac{1}{2}$
Chemistry,	1
Physiography,	$\frac{1}{2}$
Physiology,	$\frac{1}{2}$
Agriculture, ²	$\frac{1}{2}$ or 1
Botany, ²	$\frac{1}{2}$ or 1
Geology, ²	$\frac{1}{2}$
Physics, ²	1
Zoölogy, ²	$\frac{1}{2}$
Commercial geography, ³	$\frac{1}{2}$
Drawing, ³	$\frac{1}{2}$
Manual training, ³	$\frac{1}{2}$ or 1

PRESENTATION OF NOTE-BOOKS.—The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 1).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificate should not present note-books; but their certificate must state that note-books have been satisfactorily completed.

D. STATEMENT⁴ OF PREPARATION REQUIRED FOR ADMISSION.

In some cases the requirements of the College Entrance Examination Board are here mentioned. A pamphlet containing detailed explanation of these requirements can be had of the Board for 10 cents. Address sub-station 84, New York City.

AGRICULTURE.—Owing to the wide divergence of the methods of teaching agriculture in the public schools, the student will be required to bring a statement from the principal of the amount and

¹ If but one elective unit be offered, it must be in the same language as that offered to meet the two-year language requirement.

² Note-book required as part of preparation will be credited as part of the examination.

³ Certification necessary in these subjects; no examinations given.

⁴ In alphabetical order by subjects.

kinds of work accomplished and of the text-books used. The examination will be based somewhat upon this information; but it will call for not less than one-half year of creditable work of high school grade.

BOTANY. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary text-book study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Stevens's "Introduction to Botany" and Bergen and Davis's "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit; and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

CHEMISTRY. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from such text-books as Newell's "Descriptive Chemistry" or Remsen's "Elements of Chemistry," with laboratory work on the general properties of the common elements, some of the experiments being quantitative. The keeping of a note-book is required.

COMMERCIAL GEOGRAPHY. — Preparation should be given in a course equivalent to that laid down in Adams's "Commercial Geography," Trotter's "Geography of Commerce," or a similar work.

DRAWING. — Applicants may offer either freehand or mechanical drawing, or both. They must be able to make an accurate freehand sketch, in either outline or light and shade, of the appearance of a group of geometric solids, and have a sufficient knowledge of perspective to enable them to draw correctly a simple geometric model from memory; or, if they present mechanical drawing, they must have considerable working familiarity with drawing instruments, and be able to make an accurate inked working drawing, in orthographic projection, of some simple object. Emphasis is laid on facility in doing good freehand lettering. For a limitation of the work that may be presented see "Manual Training."

ENGLISH. — Preparation in English should develop in the candi-

date (1) ability to express himself well and correctly in his mother tongue, and (2) ability to penetrate through language to the meaning that underlies it.

All candidates for admission — whether by examination or by certification — are urged to secure a thorough training in composition, in which at least part of the subjects written on shall be derived from personal observation, experience and thought. They are urged to cultivate especially, in all their writing, the habit of correctness in spelling, grammar, punctuation, sentence structure and paragraph building. This habit will be of much greater help to them in their work in the college than will mere knowledge of the prescribed books.

In the examination, direct questions may be put, including questions upon grammar. Several compositions, each about one hundred and fifty words long, will be required, including papers to test the candidate's ability to think and write clearly, either on matters involving personal experience or on topics involving knowledge of the books. All candidates received as members of the freshman class are expected to be able — as a result of their study of the books prescribed "For Study and Practice" — to paraphrase or interpret, with some insight, unfamiliar verse or prose of medium difficulty, in which the meaning does not depend on anything outside the passage itself; and, as part of every examination, at least one passage is given for such interpretation.

The list of books for 1911-12 is made up from the list recommended by the Conference on Uniform Entrance Requirements in English. The examination will be based upon these; but an applicant who has prepared upon other books of the longer list will be examined thereon if he notify the Department of English of his wish before the first day of June preceding the examinations.

For 1911:—

(a) For reading and composition practice: Shakspeare's "Merchant of Venice" and "Julius Cæsar;" the "Sir Roger de Coverley Papers" in "The Spectator;" Franklin's "Autobiography;" Scott's "Ivanhoe;" Hawthorne's "House of the Seven Gables;" Dickens's "A Tale of Two Cities;" Scott's "The Lady of the Lake;" Macaulay's "Lays of Ancient Rome;" Tennyson's "Garth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur."

(b) For detailed study and practice: Shakspeare's "Macbeth;" Milton's "Lycidas," "Comus," "L'Allegro" and "Il Penseroso;" Burke's "Speech on Conciliation with America," or Washington's

“Farewell Address” and Webster’s “First Bunker Hill Oration;” Macaulay’s “Life of Johnson” or Carlyle’s “Essay on Burns.”

For 1912:—

(a) For reading and composition practice: Shakspeare’s “As You Like It” and “Julius Cæsar;” Franklin’s “Autobiography;” Goldsmith’s “The Deserted Village;” Dickens’s “A Tale of Two Cities;” George Eliot’s “Silas Marner;” Irving’s “Sketch Book;” Scott’s “The Lady of the Lake;” Byron’s “Mazeppa” and “The Prisoner of Chillon;” and Macaulay’s “Lays of Ancient Rome.”

(b) For thorough study and practice: Shakspeare’s “Macbeth;” Milton’s “Comus,” “L’Allegro” and “Il Penseroso,” or Tennyson’s “Gareth and Lynette,” “Lancelot and Elaine” and “The Passing of Arthur;” Burke’s “Speech on Conciliation with America,” or Washington’s “Farewell Address” and Webster’s “First Bunker Hill Oration;” Macaulay’s “Life of Johnson,” or Carlyle’s “Essay on Burns.”

For 1913, 1914, 1915:—

English Grammar and Composition.—Command of correct and clear English (spoken or written) requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, paragraphs, and the different kinds of whole composition, including letter writing, should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise narration, description and easy exposition and argument based upon simple outlines. It is advisable that subjects for this work be taken from the student’s personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

Literature.—Ability to read with accuracy, intelligence and appreciation is sought through study of books included in two lists, headed respectively “Reading” and “Study,” from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud, and encouraged to commit to memory some of the more

notable passages, both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads, and with their place in literary history.

(a) Reading: The aim of this course is to foster in the student the habit of intelligent reading, and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from which at least ten units (each unit being set off by semicolons) are to be selected, two from each group:—

I. The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of books XI., XIII., XIV., XV., XVII., XXI.; Virgil's "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any unit of this group a unit from any other group may be substituted.

II. Shakspeare's "Merchant of Venice;" "Midsummer Night's Dream;" "As You Like It;" "Twelfth Night;" "Henry the Fifth;" "Julius Cæsar."

III. Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" either Scott's "Ivanhoe" or "Quentin Durward;" Hawthorne's "House of the Seven Gables;" either Dickens's "David Copperfield" or "A Tale of Two Cities;" Thackeray's "Henry Esmond;" Mrs. Gaskell's "Cranford;" George Eliot's "Silas Marner;" Stevenson's "Treasure Island."

IV. Bunyan's "Pilgrim's Progress," Part I.; "The Sir Roger de Coverley Papers" in "The Spectator;" Franklin's "Autobiography" (condensed); Irving's "Sketch Book," Macaulay's "Essays on Lord Clive" and "Warren Hastings;" Thackeray's "English Humourists;" selections from Lincoln, including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address and the letter to Horace Greeley, along with a brief memoir or estimate; Parkman's "Oregon Trail;" either Thoreau's "Walden," or Huxley's "Autobiography" and selections

from "Lay Sermons," including the addresses on "Improving Natural Knowledge;" "A Liberal Education" and "A Piece of Chalk;" Stevenson's "Inland Voyage" and "Travels with a Donkey."

V. Palgrave's "Golden Treasury" (first series), books II. and III., with especial attention to Dryden, Collins, Gray, Cowper and Burns; Gray's "Elegy in a Country Churchyard" and Goldsmith's "Deserted Village;" Coleridge's "Ancient Mariner" and Lowell's "Vision of Sir Launfal;" Scott's "Lady of the Lake;" Byron's "Childe Harold," Canto IV., and "Prisoner of Chillon;" Palgrave's "Golden Treasury" (first series), book IV., with especial attention to Wordsworth, Keats and Shelley; Poe's "Raven," Longfellow's "Courtship of Miles Standish," and Whittier's "Snow Bound;" Macaulay's "Lays of Ancient Rome" and Arnold's "Sohrab and Rustum;" Tennyson's "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Hervé Riel," "Pheidippides," "My Last Duchess," "Up at a Villa—Down in the City."

(b) Study: This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. For this close reading are provided a play, a group of poems, an oration and an essay, as follows:—

Shakspeare's "Macbeth;" Milton's "L'Allegro," "Il Penseroso" and "Comus;" either Burke's "Speech on Conciliation with America," or both Washington's "Farewell Address" and Webster's "First Bunker Hill Oration;" either Macaulay's "Life of Johnson," or Carlyle's "Essay on Burns."

*Examination.*¹—However accurate in subject-matter, no paper will be deemed satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which may be taken as a preliminary, and the other as a final.

The first part of the examination will be based upon ten units chosen, in accordance with the plan described earlier, from the lists headed reading; and it may include also questions upon grammar

¹ Read in connection with this statement the first three paragraphs under "English," pp. 27, 28.

and the simpler principles of rhetoric, and short compositions upon topics drawn from the student's general knowledge or experience. On the books prescribed for reading, the form of the examination will usually be the writing of short paragraphs on several topics which the candidate may choose out of a considerable number. These topics will involve such knowledge and appreciation of plot, character-development and other qualities of style and treatment as may be fairly expected of boys and girls. In grammar and rhetoric, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors.

The second part of the examination will include composition and those books comprised in the list headed study. The test in composition will consist of one essay or more, developing a theme through several paragraphs; the subjects will be drawn from the books prescribed for study, from the candidate's other studies and from his personal knowledge and experiences quite apart from reading. For this purpose the examiner will provide several subjects, perhaps five or six, from which the candidate may make his own selections. The test on the books prescribed for study will consist of questions upon their content, form and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their other works, and the periods of literary history to which they belong.

ENGLISH, ELECTIVE. — To secure a fourth entrance credit in English, the applicant should do (*a*) the equivalent of three years' work, five periods weekly (required English), and also (*b*) the equivalent of a fourth year's work, five periods weekly. Applicants not certified with a fourth entrance credit will be examined. In order, however, that examination questions may be prepared, the applicant for examination should notify the Department of English by the first of June preceding the examinations, stating which English subject or subjects he wishes to present.

Subjects accepted. — The applicant may offer (*a*) any one of the subjects stated hereunder, or (*b*) any two of these subjects in combination.

(*a*) History of American literature.

(b) History of English literature (or lives of the great authors).

(c) Classics other than those read to meet the three-credit requirement, the applicant to present a complete list of his readings. The reading for the fourth credit should be of the same detailed, careful kind as is given the books prescribed for "Reading and Practice" in the official list of entrance requirement readings.

(d) Advanced composition.

(e) History of the English language.

(f) Advanced high school grammar.

Advanced Standing in College. — Whether advanced standing shall be given applicants entering with a fourth credit in English will be determined by consideration of each case individually. Much weight is given to the ability of the student to express himself correctly and clearly, to think clearly, and to grasp the meaning of printed language. A special examination will be given in the opening week of college, notice of which will be posted on the English bulletin board.

Presentation of Note-books and Themes. — Applicants for examination, either for fourth-unit credit or for advanced standing, are advised to present the note-books, themes, etc., prepared by them in the preparatory school, as an aid toward determining their proficiency.

FRENCH. — The necessary preparation for this examination is stated in the description of the two-year course in elementary French recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year French (elective subjects for admission). — For a single credit unit in French as an elective subject for entrance, when required units have been offered in French, the work described by the College Entrance Examination Board as "intermediate" is expected. For two credit units, the work described as "intermediate" and "advanced" is expected.¹

GEOLOGY. — Grouped with zoölogy, which see.

GERMAN. — The entrance requirements in German conform to those of the College Entrance Examination Board for elementary German (the standard two-year requirements).¹

Third and fourth year German (elective subjects for admission). — For a single credit unit in German as an elective subject for entrance, when required units have been offered in German, the

¹If the two required and two elective modern language units are offered in French and German, the work known as "Elementary" may be offered in both cases.

work described by the College Entrance Examination Board as "intermediate" is expected. For two credit units, the work described as "intermediate" and "advanced" is expected.

GREEK. — Greek will receive credit as an elective requirement upon either examination or certification, as follows:—

1. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from the first two books of Xenophon's "Anabasis;" and (*b*) the translation of passages of Attic prose at sight.

2. Three credit units will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages selected from the first book of Homer's "Iliad," and (*b*) translation of passages of Homer's "Iliad" at sight, with questions on the forms and constructions of the passages.

HISTORY. — Of the one and one-half required units the one-half unit must be offered in United States history and civics, and the one required unit must be offered in either ancient history, medieval and modern history, English history or general history. Either one or two elective units in any one of the historical subjects here named may be offered, provided that such units may not be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good text-books, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on an outline map.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers, in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery, in United States history and civics.

LATIN. — Latin will receive credit as an elective requirement upon either examination or certification, as follows:—

1. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," books I. to IV., or an

equivalent, and from Cicero's "Orations against Catiline;" and (b) the translation of passages of Latin prose at sight.

2. Three credit units will be allowed if, in addition to the above, satisfactory proficiency be shown in (a) the translation of a passage or passages selected from books I. and II. of Virgil's "Æneid;" and (b) the translation into Latin prose of a passage of connected English narrative based on some portion of Cæsar's "Gallic War," books I. to IV.

MANUAL TRAINING. — An entrance credit of one-half or one unit is allowed for manual training, on the presentation of a certificate from the principal of the school showing the scope and character of the applicant's work. The preparation may include mechanical drawing, working in wood, metals, leather, etc. When mechanical drawing is presented as a part of the work in manual training, no other credit for drawing will be allowed. No examination is given in this subject; applicants must present certificates to secure credit.

MATHEMATICS. — (a) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynomials and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations; problems depending upon quadratic equations; the binomial theorem for positive integral exponents, the formulas for the n th term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(b) *Elective.* — Solid Geometry: The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the sphere and spherical triangle; the solution

of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

PHYSICS. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work should consist of both class-room work and laboratory practice. The work covered in the class room should be equal to that outlined in Hall & Bergen's "Text-book of Physics;" the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination paper submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

PHYSIOLOGY. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body: Briefer Course."

ZOÖLOGY, PHYSIOGRAPHY, GEOLOGY. — The following suggestions are made concerning preparation for admission in the subjects named above:—

For physiography, Davis's "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, text-books entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Text-book in General Zoölogy." For geology, A. P. Brigham's "A Text-book of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present a note-book, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

E. ADMISSION TO ADVANCED STANDING.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this requirement, a student transferring to this college from another college or university of recognized standing must present the following credentials:—

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. OTHER INFORMATION ABOUT ENTRANCE.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)

2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.

3. Candidates must receive credit for twelve units out of the total number required for entrance, and will be conditioned in those subjects not passed. No candidate deficient in both algebra and plane geometry will be admitted. For a special provision permitting entrance with a condition in English, see footnote, p. 24.

4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination, in the week following the Thanksgiving recess. (2) Second entrance condition examination, in the sixteenth week of the first semester.

5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.

6. Examinations in part of the subjects required for entrance may be taken one year before entering college.

7. For information concerning expenses, scholarships, etc., see "General Information."

8. For information concerning admission to short courses see "Short Courses."

9. All requests for information concerning admission of unclassified students should be addressed to Prof. E. A. White, chairman of committee on unclassified students.

G. UNCLASSIFIED STUDENTS.

Students not candidates for a degree (unclassified students) are admitted under the following provisions:—

1. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-years high school course or its equivalent, and furnish satisfactory testimonials as to moral character.

2. No applicant under twenty-one years of age will be admitted as an unclassified student.

3. Each unclassified student must take from the regular courses a minimum of twelve credit hours a week.

4. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

5. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 75 per cent. An unclassified student who passes in less than two-thirds of his work will be dropped from college.

6. All unclassified students are subject to the supervision of a special committee.

7. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than four semesters without the special permission of the faculty.

8. Unclassified students are subject to the regulations applying to classified students.

COURSES OF INSTRUCTION.

A. TABLE OF UNDERGRADUATE SUBJECTS.

[The figures indicate the number of credit hours a week. For details, see the descriptions of courses.]

FRESHMAN YEAR.

First Semester.

[All work required.]

English,	4
French or German, ¹	4
Algebra,	5
Chemistry,	3
Hygiene,	1
Physical education, ²	2
Public speaking (at option of instructor),	1
College life (attendance required without credit).	

19 or 20

Second Semester.

[All work required.]

English,	4
French or German,	4
Geometry and trigonometry,	5
Chemistry,	3
Elementary agriculture,	2
Physical education,	2
Public speaking (if not taken in semester 1),	1

20 or 21

SOPHOMORE YEAR.

First Semester.

[All work required.]

English,	2
French or German,	3
Agronomy,	3
Zoölogy,	3
Physics,	5
Physical education,	2

18

¹ Students may continue in college the language that they present for admission, or they may take the other; but they must continue whichever language they so elect until the end of the first semester of the sophomore year. Eleven college credits are required in this language.

² Physical education includes military training.

Second Semester.

[All courses under "Required," with any two of those under "Elective."]

[Required.]

[illegible]

13

[Elective.]

French or German,	} each 3 hours. Any two, . . . 6
Animal husbandry,	
Geology, . . .	
Physics, . . .	
Chemistry, . . .	
Surveying, . . .	

19 or 18

JUNIOR AND SENIOR YEARS.

In the junior and in the senior year, work must be taken each semester amounting to not fewer than seventeen nor more than twenty credits.

[Required.]

The following-named subjects are required after the sophomore year, as indicated:—

Physical education, two credits each semester of junior year,	4
Political science (Course 1, Economics),	3
English (any of the elective courses except Literature 15 and 16),	3

[Elective.]

Unless otherwise stated, elective courses are open to both juniors and seniors. Elections are subject to such provisions as either the faculty or the instructors in the courses may declare. In electing courses, students will prepare the statement of their elections strictly in this form:—

For semester ^{one}_{two} of 1910-11, I elect these courses, namely: —

No. of Course in Catalogue.	Name of Course in Catalogue.

(Signed) _____

Class of 191____

[Only those courses are here mentioned which are entirely elective; some courses that are open to election by part of the students but are required courses for others are omitted. For such courses, see under the respective department headings the descriptions of "Required Courses."]

Agricultural education, 1, 2, 3, 4, 5, 6.

Agriculture: —

Agriculture, 3.

Agronomy, 3, 4, 6, 8.

Animal husbandry, 2, 3, 4, 5, 6.

Dairying, 1, 2, 3, 4.

Farm administration, 3, 4.

Botany, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14.

Chemistry, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15, 17, 18, 19.

Entomology, 2, 3, 4.

Horticulture: —

Horticulture, 3, 4, 6.

Pomology, 1, 2, 3, 4.

Floriculture, 1, 2, 3, 4.

Landscape gardening, 1, 2, 3, 4, 5, 6, 7, 8.

Forestry, 1, 2.

Market gardening, 2, 3.

Drawing, 1, 2.

Humanities: —

English: —

English language and journalism, 9, 10, 15, 16, 17.

Literature, 9, 10, 13, 14, 15, 16, 18.

Public speaking, 8, 9, 10.

Modern European languages: —

French, 6, 7, 8.

Spanish, 1, 2.

German, 6, 7, 8.

Music, 1, 2.

Political science, 2, 3, 4, 5, 6, 8.

Mathematics, 7, 10; Physics, 6, 9, 15; Engineering, 8, 11, 12, 13, 14.

Military science, 11, 12.

Physical education, 7, 8, 9, 10.

Rural social science: —

Agricultural economics, 4, 5, 6, 7, 9, 10.

Rural sociology, 12, 16.

Veterinary science, 1, 3, 4.

Zoölogy and geology: —

Zoölogy, 3, 4, 5, 6, 7, 8, 9.

Geology, 2.

B. UNDERGRADUATE COURSES.

[All courses given in the first semester bear odd numbers; all given in the second semester bear even numbers. Studies are pursued in courses, "course" implying the study given a subject within one semester, without regard to the total number of hours or to the number of credits. Under the heading "Required Courses" are classified all courses that are specifically required of any group of students, although in some cases the same courses are open to other students as electives. The special mention of certain courses as prerequisite to other courses does not imply that no courses but those so mentioned are "preliminary or preparatory" within the meaning of paragraph 9, page 9 of the Rules. Announcements of courses that are not given in 1910-11 are inclosed in brackets.]

Department of Agricultural Education.

Professor HART and Assistant Professor JENKS.

Elective Courses.

1. MEANING OF EDUCATION (PSYCHOLOGY).—A study of the development, structure and function of the nervous system with reference to the sense organs; relation of mind to the nervous system; growth and nature of mental processes; the activities of the mind in the process of learning. Text-book, lectures, discussion, and collateral readings and reports; 3 hours. Credit, 3.

Professor HART.

2. VOCATIONAL EDUCATION (HISTORY AND PHILOSOPHY).—A survey of educational, religious and social movements with reference to their vocational aspects; the growth of educational institutions as influenced by science and industry. Lectures, collateral readings, reports, and a thesis on some phase of industrial education; 3 hours. Credit, 3.

Professor HART.

3. METHODS.—A study of mental growth; the theory and practice of teaching; school organization and methods of instruction; the place and function of agriculture in the course of study. Primarily for those who have had Course 1 or 2; 2 hours. Credit, 2.

Professor HART.

4. TEACHERS' AGRICULTURE.—Designed primarily for those who intend to teach; may be taken in connection with Course 3. The work consists of the selection and review of such parts of the courses in agriculture, horticulture and the biological and physical sciences as are adapted to the work of the public schools; planning, and practical work in school gardens; decoration of school grounds;

equipment and conduct of playgrounds. One lecture period, 2 two-hour laboratory periods. Credit, 3.

Professor HART and Assistant Professor JENKS.

5. SEMINAR IN EDUCATION.—For students who have had courses 1, 2 and 3, or an equivalent. Topics that may be taken up for rather exhaustive study are: legislation and agricultural education, the place and value of agricultural science in school courses, etc. Seniors and graduate students; 2 hours. Credit, 2.

Professor HART.

6. SEMINAR IN EDUCATION.—As stated under Course 5.

Professor HART.

DIVISION OF AGRICULTURE.

Professor FOORD, Dr. BROOKS, Associate Professor LOCKWOOD, Associate Professor McLEAN,¹ Assistant Professor HASKELL, Mr. GRIBBEN,² Mr. ROBINSON.

Sections.

AGRICULTURE.

AGRONOMY.

ANIMAL HUSBANDRY.

DAIRYING.

FARM ADMINISTRATION.

Agriculture.

Required Courses.

2. ELEMENTARY AGRICULTURE.—A brief course touching upon the application of science to the common things of the farm. The work of the agricultural experiment stations and its relation to farm practice will be considered. Lectures, text-book and laboratory. Freshmen; 1 laboratory and 1 lecture period. Credit, 2.

Elective Courses.

3. AGRICULTURAL SEMINAR.—A brief survey of current agricultural literature, open to juniors and seniors electing work in the Division of Agriculture. Topics will be assigned and reports required. One hour. Credit, 1. Professor FOORD.

¹ Beginning with second semester.

² Up to Jan. 20, 1911.

*Agronomy.**Required Courses.*

1. SOILS AND FERTILIZERS. — A study of the formation, classification and physical and chemical properties of soils. This is followed by study of methods of soil improvement and of maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments. Prerequisites, Chemistry 1 and 2. Sophomores; 3 lecture hours. Credit, 3.

Assistant Professor HASKELL.

Elective Courses.

3. FIELD AND FORAGE CROPS. — History, classification, cultivation and harvesting, commercial grading and valuation. The crops studied are the cereal grains, grasses, legumes, forage crops, and those "money crops" of importance in New England. The laboratory work includes the testing of the purity and vitality of the seeds of the different field crops, valuation and judging thereof, and study of the varieties suited to New England conditions. Prerequisites, Agronomy 1 and Botany 2; 2 lectures and 1 laboratory period. Credit, 3.

Assistant Professor HASKELL.

4. FIELD CROP IMPROVEMENT. — A study of the influences determining the yield and value of field crops, and of methods of selecting seed and plant with reference to crop improvement. Particular attention is given to the breeding of plants for early maturity, hardiness and disease resistance, so as to fit them to New England conditions. Lectures, laboratory and field work. Prerequisite, Agronomy 3; 1 lecture and 1 laboratory period. Credit 2.

Assistant Professor HASKELL.

6. ADVANCED SOILS. — Theoretical and practical work on irrigation and drainage; soil survey, with the view of observing the relation between types of soil and natural vegetation; soil mapping. Lectures, laboratory and library work; 1 lecture and 2 laboratory periods. Prerequisites, Agronomy 1 and Mathematics 8. Credit, 3.

Assistant Professor HASKELL.

8. MANURES AND FERTILIZERS. — An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers.

and leading up to the views at present accepted. Each of the important manures and fertilizers will be discussed, its origin and its chemical and physical characteristics being considered. Each material taken up will be studied in relation to its capacity to supply plant food and to its effects upon soil texture, moisture, temperature and flora. Considerable attention will be devoted to consideration of the experimental work which has been done, and which is now in progress, in manures and fertilizers. Prerequisite, Agronomy 1; 3 lectures a week, with occasional seminars. Credit, 3.

Dr. Brooks.

Animal Husbandry.

Elective Courses.

2. TYPES AND BREEDS OF FARM ANIMALS. — A general introductory course. The development, characteristics and adaptability of the more common breeds of farm live stock. Lectures; Plumb's "Types and Breeds of Farm Animals." Sophomores; 2 lecture periods and 1 laboratory period. Credit, 3.

Associate Professor McLEAN.

3. PRINCIPLES OF LIVE STOCK IMPROVEMENT. — A careful study of the principles of inheritance, and a discussion of methods of improving herds or individual animals, of crossing and grading in the production of market and farm stock. Prerequisite, Course 2; 3 lecture periods; library references. Credit, 3.

Mr. GRIBBEN, [Associate Professor McLEAN.]

4. DAIRY CATTLE. — Score cards as applied to breed type and their use in scoring for advanced registry; herd book study. One object is to acquaint the student with the various families of the different breeds, their producing powers and external characteristics. The men who will represent the college in judging contests will be chosen from those electing this course, according to the merit of their work. Text-book, lectures and laboratory work; text-book, Craig's "Live Stock Judging." Prerequisite, Course 2; 2 laboratory periods. Credit, 2. Associate Professor McLEAN.

5. HORSES, SHEEP AND SWINE. — A course similar to Course 4, but dealing with different classes of stock. Of necessity, the study cannot be so detailed as that made in the preceding course, yet a good working knowledge of the judging of these classes is aimed at.

The course will consist largely of judging practice, with some periods devoted to lectures, covering such topics as unsoundness in horses and the determination of age in domestic animals. Text-book, lectures and laboratory work. Craig's "Live Stock Judging." Prerequisite, Course 2; 2 laboratory periods. Credit, 2.

Mr. GRIBBEN, [Associate Professor McLEAN.]

6. FEEDING AND MANAGEMENT OF FARM LIVE STOCK. — The principles of nutrition; their relation to stock feeding; the balanced ration; feeding standards; feed stuffs, method of manufacture, economy to the feeder; economical feeding and management of farm animals; feeding for special purposes (as of dairy cows for records and in preparation for public sales or exhibitions). Text-books and lectures; text-books, Henry's "Feeds and Feeding" and Jordan's "Feeding Farm Animals;" experiment station bulletins. Students electing this course are advised to present Chemistry 5 and 6 and register in veterinary science; 3 hours. Credit, 3.

Associate Professor McLEAN.

Dairying.

Elective Courses.

1. MILK AND ITS COMPOSITION. — The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; methods in economic milk production; methods for testing herds and developing them to higher efficiency; the study of analysis of milk products by use of the Babcock test for fat, test for acidity and adulteration, and ordinary preservatives; moisture tests for butter; problems. Must be preceded or accompanied by Animal Husbandry 3; 2 lecture hours and 1 laboratory period. Credit, 3.

Associate Professor LOCKWOOD.

2. MARKET MILK. — A study of the market milk conditions, extent and development of the business, supply and delivery; food value of milk and its use as food; milk and its relation to the public health; methods for the proper handling and preparing of milk and cream for direct consumption; certified milk, requirements and production; pasteurizing, sterilizing, standardizing and modifying; milk laws and inspection; a study of bacteriology relative to milk and dairy work. Must be preceded or accompanied by Animal Husbandry 4. Prerequisite, Course 1; 2 lecture hours and 1 laboratory period. Credit, 3.

Associate Professor LOCKWOOD.

3. BUTTER MAKING. — A study of hand and factory separators, separator construction and cream separation; handling milk and cream for butter making on the farm and in the factory; preparation of home-made and commercial starters, and ripening cream; churning; recording work; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy-building construction; plans for dairy buildings, arrangement, ventilation, light, sanitation; dairy machinery and care thereof; practical mechanics as applied to the creamery; cement construction as related to dairy construction work. Prerequisites, Courses 1 and 2; 2 lecture hours and 1 laboratory period. Credit, 3.

Associate Professor LOCKWOOD.

4. MANUFACTURED MILK PRODUCTS. — Manufacture of other dairy products than butter. Cheddar and fancy cheeses; condensed milks; whey butter, cottage cheese, ice cream, casein, milk powder, etc.; dairying in other countries; library work. Must be preceded or accompanied by Animal Husbandry 6. Prerequisites, Courses 1, 2 and 3; 2 lecture hours and 1 laboratory period. Credit, 3.

Associate Professor LOCKWOOD.

Farm Administration.

Elective Courses.

3. FARM EQUIPMENT. — A study of the material equipment of the farm aside from the land; farm buildings, their location, plan and arrangement; water supply; fencing problems; farm power; farm machinery; wagons. Prerequisite, Agronomy 1, Animal Husbandry 2 and Mathematics 5; 2 laboratory periods and 1 lecture hour. Credit, 3.

Professor FOORD.

4. FARM MANAGEMENT. — The organization of the farm as a business enterprise. A discussion and study of some of the problems that confront the modern farmer, such as the choice of a farm, systems and types of farming, labor, marketing, records and farm accounts. Prerequisites, Agronomy 1 and 3 and Animal Husbandry 2; 2 lecture or recitation hours and 1 seminar period. Credit, 3.

Professor FOORD.

Department of Botany.

Professor STONE, Assistant Professor OSMUN.

[The object of the courses in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. Undergraduate work extending through five semesters is offered. Considerable latitude is allowed students in the senior year in their electives; and, besides the courses here outlined, students often take up the study of histology or of systematic botany, the microscopic examination of pure and adulterated human and cattle foods, spices and drugs, etc. Students sufficiently prepared are occasionally permitted to undertake special physiological and pathological investigations. A botanical conference is held monthly wherein new problems in botanical science are considered by graduate students and the seniors who elect botany.]

Required Courses.

2. HISTOLOGY, PHYSIOLOGY, MORPHOLOGY AND CLASSIFICATION OF PLANTS. — This course is divided into two parts: Part I. extends to the first week in May; Part II. occupies the remainder of the semester. Part I.: Devoted to study of the minute structure and the function of stems, leaves, roots and seeds, and of the chemical composition of plant constituents. The laboratory work consists largely of microscopic study of plant structures, with some time devoted to chemical tests for plant constituents. The lectures aim to amplify and interpret the laboratory work, and to explain the inter-relation of structure and function. Part II.: The laboratory periods are employed in the study of morphology and plant analysis. Lectures are given in morphology, ecology, evolution and taxonomy. Each student is required to collect and prepare an herbarium of 75 species of native plants. Gray's "New Manual of Botany" is used in determining and naming plants. Though only one lecture period is scheduled for this course, it is understood that laboratory hours may be used for lectures at the discretion of the instructor. Sophomores; 3 two-hour laboratory periods and 1 lecture hour. Credit, 4. Assistant Professor OSMUN.

Elective Courses.¹

3. CRYPTOGAMIC BOTANY. — Systematic study of typical forms of the lower plants (bacteria, algæ, fungi, lichens, mosses and ferns); instruction in laboratory technique and methods, and the making of herbaria of lichens, mosses and ferns. Laboratory work and lectures; field excursions for the purpose of observing environmental habits and collecting material for laboratory study; collateral reading. This course is intended for those students who wish to specialize in biology; its purpose is to afford more thorough

¹ Students electing any of the junior work may take botany in their senior year, and those specializing in chemistry may take plant physiology in their senior year without having had the junior work in botany.

scientific training than is offered in Course 5, and students electing this course will attend the lectures in Course 5. Juniors; 3 two-hour laboratory periods and 1 lecture hour. Credit, 4.

Assistant Professor OSMUN.

4. CRYPTOGRAMIC BOTANY. — This is a continuation of Course 3. Prerequisite, Course 3. Juniors; 1 two-hour laboratory period and 1 lecture hour. Credit, 2.

Assistant Professor OSMUN.

5. PLANT PATHOLOGY. — This course comprises a study of the common diseases of crops and consideration of the methods for their prevention and control, and is intended especially for students in horticulture and agriculture. Laboratory work and lectures. The work in pathology is preceded by a brief study of the lower cryptogams. Juniors; 1 two-hour laboratory and 1 one-hour lecture period. Credit, 2.

Professor STONE and Assistant Professor OSMUN.

7. PLANT PATHOLOGY. — This course includes a study of the diseases of one or more crops and the methods of controlling them. Laboratory work and lectures, together with extensive reading of experiment station literature. The course is intended for those who wish to become more familiar with the diseases of one or more groups of economic plants. Seniors; those students continuing in botany must take Course 8; 3 three-hour laboratory periods and 1 lecture period. Credit, 5.

Professor STONE.

8. PLANT PATHOLOGY. — As stated in Course 7. Prerequisite, Course 7.

Professor STONE.

9. ECONOMIC FUNGI. — This course comprises the study of economic fungi from a taxonomic point of view, and is intended for those who wish a more comprehensive knowledge of the phylogenetic relationships of fungi. Laboratory work and lectures. Tubeuf & Smith's "Diseases of Plants" is used as a guide, with special monographs on fungi and with the more important experiment station literature treating of the life history of fungi. Seniors; must be followed by Course 10; 2 or 3 three-hour laboratory periods and 1 one-hour lecture period. Credit, 4 or 5.

Professor STONE.

10. ECONOMIC FUNGI. — As stated in Course 9. Prerequisite, Course 9.

Professor STONE.

11. PLANT PHYSIOLOGY. — This course is largely experimental, and is especially adapted to the needs of students who are taking chemistry. Laboratory work and lectures; various handbooks on plant physiology. Seniors; must be followed by Course 12; 3 three-hour laboratory periods and 1 one-hour lecture period. Credit, 5.

Professor STONE.

12. PLANT PHYSIOLOGY. — As stated in Course 11. Prerequisite, Course 11.

Professor STONE.

13. PHYSIOLOGY AND PATHOLOGY OF SHADE TREES. — This course includes a comprehensive study of the diseases, structure and functions of trees and shrubs, and of every agency which in any way affects shade trees. Laboratory work and lectures; extensive reference reading. Designed for those students who intend to take charge of parks or large estates, or to become tree wardens, city foresters, landscape gardeners or professional advisers and caretakers. Seniors; must be followed by Course 14; 2 three-hour laboratory periods and 1 one-hour lecture period. Credit, 4.

Professor STONE.

14. PHYSIOLOGY AND PATHOLOGY OF SHADE TREES. — As stated in Course 13. Prerequisite, Course 13.

Professor STONE.

Department of General and Agricultural Chemistry.

Professor WELLINGTON, Associate Professor CHAMBERLAIN, Assistant Professor HOWARD.

[The courses in chemistry aim to teach accurate observation, logical thinking and systematic and constant industry, together with a comprehensive knowledge of the subjects presented. Instruction is given through text-books, lectures and a large amount of laboratory work under supervision. The laboratory work at first consists of the study of the properties of elementary matter, the analysis of simple combinations, and their artificial preparation. This is followed by the quantitative analysis of salts, minerals, soils, fertilizers, and the chemistry of various manufacturing industries, especially those of agricultural interest, such as are concerned in the production of sugar, starch and dairy products; the preparation of animal and plant foods, their digestion, assimilation and economic use; and the official analysis of soils, insecticides, fungicides, waters, milk, wine, and other animal and vegetable products.]

Required Courses.

1. THE NON-METALS. — An introduction to chemical laws. The commoner non-metallic elements, their occurrence in nature, and their uses in the arts, are studied. Lectures and laboratory exercises. Freshmen; 4 hours. Credit, 3.

Assistant Professor HOWARD.

2. THE COMMON METALS.—This course extends the study of Course 1 to the metals common in the arts, and includes blowpipe analysis and elementary determinative mineralogy. Lectures, recitations and laboratory exercises. Prerequisite, Course 1. Freshmen; 4 hours. Credit, 3.

Assistant Professor HOWARD.

Elective Courses.

3. GENERAL CHEMISTRY.—This course makes a more thorough study of the physical laws and typical reactions than is made in Courses 1 and 2. For all students intending to specialize in chemistry this course is required. Prerequisite, Course 2. Lectures, 1 hour; laboratory, 4 hours. Credit 3.

Assistant Professor HOWARD.

4. QUALITATIVE ANALYSIS.—A course in the systematic analysis of the important metals and acids and their salts. Students electing advanced courses in chemistry should take this course. Lectures and laboratory work; Medicus's "Qualitative Analysis." Prerequisite, Course 2. Sophomores; 6 hours. Credit, 3.

Assistant Professor HOWARD.

5. ORGANIC CHEMISTRY.—This course, with Course 6, continues through the junior year. The two courses are designed especially: (1) for those who are looking forward to positions as chemists in agricultural colleges or experiment stations, the United States Department of Agriculture, or similar places, and who need a knowledge of chemistry for itself; and (2) for those who are expecting to enter like positions in other sciences, and who will use their knowledge of chemistry in a secondary way. It consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry; and forms a foundation for courses in physiological chemistry and agricultural analysis, and thus for possible future work in agricultural chemical investigation. Prerequisites, Courses 1, 2 and 4. Those electing Course 5 are expected to elect Course 6. Juniors; lectures, 3 hours; laboratory, 4 hours. Credit, 5.

Associate Professor CHAMBERLAIN.

6.—As stated under Course 5.

Associate Professor CHAMBERLAIN.

7. AGRICULTURAL CHEMISTRY. — A course continuing through the two semesters of the junior year. This course and Course 8 are designed as an alternative for Courses 5 and 6. They are especially intended for those who, having completed Courses 1 and 2, do not care to continue the study of chemistry for itself, but who are planning to enter practical agricultural work and desire a somewhat further knowledge of chemistry as it is related directly to agriculture and agricultural problems. The work is planned in two parts, viz., *Course 7, Inorganic Agricultural Chemistry*, the study of the general composition, properties and reactions of soils and fertilizers, and in addition to this the study of some of the common materials of construction, such as tile, brick, cements, paints, oils, etc.; and *Course 8, Organic Agricultural Chemistry*, the study of plants and animals as to composition, nutritive value and general processes of nutrition and growth, and also the study of products manufactured from them, such as milk, butter, sugar, maple syrup, denatured alcohol, wood pulp, paper, etc. The treatment of the subject in both of these courses is entirely general, avoiding all complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the chemical aspect of agricultural processes and products. Prerequisites, Courses 1 and 2. Juniors; those electing Course 7 are expected to elect Course 8; lectures, 3 hours. Credit, 3.

Associate Professor CHAMBERLAIN.

8. — As stated under Course 7.

Associate Professor CHAMBERLAIN.

9. QUANTITATIVE ANALYSIS. — A course continuing through the two semesters of the junior year; for those who wish to acquire skill in chemical analysis. Students intending to enter experiment station or chemical-control work have here an opportunity to become familiar with the reactions and processes concerned. Prerequisite, Course 4. Juniors; those electing Course 9 are expected to elect Course 10; lectures, 1 hour; laboratory, 9 hours. Credit, 5.

Professor WELLINGTON.

10. — As stated under Course 9.

Professor WELLINGTON.

13. PHYSIOLOGICAL CHEMISTRY, VEGETABLE. — This course and Course 14 are intended to be supplementary to Courses 5 and 6 and Courses 7 and 8. To those who expect to take up scientific

work, and who have had Courses 5 and 6, Course 13 will give acquaintance with the chemistry of the physiological processes in plants, and the action of physiological substances. Together with Course 14, it gives additional training in the chemical problems of agricultural experiment station work, and it will, with the courses in analytical chemistry, fit men for such work. To those who will not take up scientific lines of work, but will follow practical agriculture, it will give additional knowledge of the facts and processes with which they will meet. It will consider more exactly and in greater detail the chemical and physiological aspect of problems which were treated generally in Courses 7 and 8. Prerequisites, Courses 5 and 6, or 7 and 8. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor CHAMBERLAIN.

14. PHYSIOLOGICAL CHEMISTRY, ANIMAL. — A continuation, or counterpart, of Course 13, but dealing with animals. Prerequisites, Courses 5 and 6, or 7 and 8. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor CHAMBERLAIN.

15. CHEMICAL PROBLEMS. — A course in the historical progress of agricultural chemistry. The inception and growth of modern knowledge in agricultural chemistry will be intimately studied for the purpose of familiarizing the student with the experimental work and the logical processes of the more notable achievements in this department of chemistry. The course includes work in the biography and literature of research, as well as general chemical history. The classic works of Liebig, Wöhler, Liebermann, Baeyer, Gilbert, Henneberg, Tollens, Fischer and others will be taken up. In the light of the studies made, present-day problems in agricultural chemistry will be examined and methods for their solution tried. Prerequisites, Courses 5 and 6, 9 and 10, 11, 13, 14. Open to students only by permission; lectures, reading and laboratory work; 1 lecture and 4 laboratory periods. Credit, 5.

Professor WELLINGTON.

17. CHEMICAL PRACTICE IN AGRICULTURE. — This course and Course 18 are divided into subcourses as follows:—

A. *Analysis of Fertilizers, Insecticides and Fungicides.* — The theory, with a large amount of practice in this subject, is given under the close supervision of a teacher. The methods followed are in the first place comparative. Then the preferred official methods

are intimately studied, especially with reference to their limitations. The students are impressed with the fact that, even at this late day, all of these methods require revision, and are only awaiting the clear head of the learned man and the expert technician for their improvement. Prerequisite, Course 4. Seniors; lectures 1 hour, laboratory 9 hours. Credit, 5.

B. Analysis of Foods and Fodders. — This course is pursued in a method uniform with that of Course 17A. Both courses are intended to fit men for experimental station and control work, as well as for research efficiency. The latest results of alimentation, physiology and the composition of foods and condiments are studied. The students will be urged to make inquiry for themselves in the fields of study. Prerequisites, Courses 5 and 6, 9 and 10, 13; co-requisite, Course 14; lecture 1 hour, laboratory 9 hours. Credit, 5.

C. Chemistry of Sugar Making and Refining. — In this course, after the chemical character of sugar and its function as a food have been determined, the theory and practice of the subjects named will be intimately studied. This involves practice in the analysis of many common chemicals, minerals and manufactured products, such as limestone, coal, boneblack, sulphites, clays, etc. The behavior of sugars and allied substances toward light, qualitatively and quantitatively, is investigated. The students are fitted for service in sugar houses and sugar refineries. Prerequisite, Courses 5 and 6; lectures 1 hour, laboratory 9 hours. Credit, 5.

D. Dairy Chemistry. — This course takes up instruction in the various processes of dairy chemistry, including chiefly the analysis of foods for dairy animals and the dairy products. Given in alternate years; given in 1910-11. Open only on permission; lectures 1 hour, laboratory 6 hours. Credit, 3. Professor WELLINGTON.

18. CHEMICAL PRACTICE IN AGRICULTURE. — As stated under Course 17. Professor WELLINGTON.

19. SANITARY CHEMISTRY. — This course is planned to bring into striking and intimate relationships many hitherto missing facts between the science of the lecture room and laboratory and the actual practice of living as it is pursued in every condition in which a person finds himself between birth and death. It is hoped that this course will impart to every one who takes it new conceptions of the functions and duties of practical life. It is believed that,

through carefully and minutely demonstrated experiments, this end will be attained. Given in alternate years; not given in 1910-11. Open only on permission; lectures 2 hours. Credit, 2.

Professor WELLINGTON.

Department of Entomology.

Professor FERNALD, Mr. SUMMERS.

[A knowledge of insects is of importance in every department of life, and particularly in connection with agriculture, horticulture, biology, landscape gardening and forestry; it therefore forms part of a general education. An introductory course in this subject is accordingly offered in the junior year. For those who desire a further knowledge of the subject, because of its importance to their future occupation, a senior course is also offered, so arranged as to be of especial value for those who expect to take up agriculture, horticulture, landscape gardening, forestry or science teaching.]

Elective Courses.

2. GENERAL AND ECONOMIC ENTOMOLOGY. — This course comprises studies in the structure of insects as applied to their identification, and in the principles of classification; a systematic examination of the different groups and of the most important economic insects of each group, including their life histories and habits, recognition of their work as shown in the collection and in the field, and methods for their control. The most important insecticides, and their preparation and application with different kinds of apparatus are also treated. Field work in collecting insects is a part of the course; and this is accompanied by laboratory work on methods of pinning, pressing and mounting insects, and of classifying them. Juniors; 4 one-hour lecture periods till about May 1; thereafter 1 one-hour lecture period and 3 two-hour laboratory or field periods. Credit, 4.

Professor FERNALD.

3. ADVANCED ENTOMOLOGY. — This course is subdivided according to the particular needs of those taking it, and is to a large degree given in the form of individual instruction.

A. *Morphology.* — Careful studies of the structure of insects belonging to each of the larger and more important orders, together with lectures on the subject, followed by the identification of insects of each of these groups and the study of the collections, to teach the use of the analytical tables and of structural characters in the determination of insects.

B. *Histology.* — Lectures on the internal anatomy and histology of the various organs, with particular reference to those affected by the various insecticides.

C. Insecticides and Apparatus.—Lectures on the chemistry, preparation and application of the different insecticides, their merits and defects, tests for detecting adulterations; and a study of other methods of insect control, together with laboratory work on adulterated materials.

D. Coccidology.—Laboratory work on methods of preserving, mounting and identifying scale insects, particular attention being given to those of greatest economic importance.

E. Bibliography.—Studies of the various entomological publications and of the methods of finding the literature on any insect.

F. Special Studies.—In these studies the insects most closely related to the future occupation of the student will receive attention. The results of these studies are brought together in the form of an essay or thesis; this will include all the essentials of what is known of the structure, life history, habits and injuries caused by each insect studied, together with methods of treatment, and a list of the best articles found in the course of the work. Comstock's "Manual for the Study of Insects" is used in the laboratory work. Seniors; prerequisite, Entomology 2; students electing 3 must also take 4; 1 one-hour lecture period and 3 two-hour laboratory or field periods. Credit, 4.

Professor FERNALD and Mr. SUMMERS.

4. ADVANCED ENTOMOLOGY. — As stated in Course 3. Prerequisite, Course 3.

Professor FERNALD and Mr. SUMMERS.

DIVISION OF HORTICULTURE.

Professor WAUGH, Professor SEARS, Professor WHITE, Associate Professor MOON, Mr. HELLER, Mr. NOYES, Mr. NORMAN, Mr. RANE.

Departments.

HORTICULTURE.

POMOLOGY.

FLORICULTURE.

LANDSCAPE GARDENING.

FORESTRY.

MARKET GARDENING (SECTION).

DRAWING (SECTION).

Department of Horticulture.

[The general subject of horticulture divides naturally into the subjects of pomology, floriculture, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore here grouped under the general designation of horticulture.]

Required Courses.

2. NURSERY PRACTICE. — This course treats of the fundamental operations of horticulture — propagation, pruning, cultivation — as related to the physiology of the plant. Lectures and practicums; Bailey's "Nursery Book" as text in propagation. Sophomores; 2 hours. Credit, 2. Mr. NORMAN.

Elective Courses.

3. PLANT MATERIALS. — This course aims to make the students familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work, and with the methods of propagating them. Prerequisite, Horticulture 2; 2 lecture periods and 1 laboratory period. Credit, 3. Professor WHITE.

4. PLANT MATERIALS. — A continuation of Course 3, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions. Prerequisite, Horticulture 3; 2 lecture periods and 1 free afternoon. Credit, 3. Professor WHITE.

6. PLANT BREEDING. — This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops. Seniors and graduates; open only to students well prepared in agricultural or horticultural subjects; 2 lecture periods and 1 two-hour laboratory period. [Not given in 1910-11.] Credit, 3.

*Department of Pomology.**Elective Courses.*

1. PRACTICAL POMOLOGY. — *General.* — A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of stock, pruning, spraying, etc. Text and reference books; field and laboratory exercises. Prerequisite, Horticulture 2. Juniors; 5 hours. Credit, 3. Professor SEARS.

2. PRACTICAL POMOLOGY. — *Special.* — The special application of the general principles discussed in Course 1 to the culture of the principal kinds of fruits, such as apples, pears, peaches, plums, cherries and quinces; grape culture and the culture of small fruits, such as blackberries, raspberries, currants, gooseberries and strawberries. Text-books, lectures and reference books; field and laboratory exercises. Prerequisites, Horticulture 2 and Pomology 1. Juniors; 5 hours. Credit, 3. Professor SEARS.

3. SYSTEMATIC POMOLOGY. — A study of the varieties of the different fruits and of nomenclature, with critical descriptions; special reference being given to relationships and classification. Text-books, laboratory and field exercises. Prerequisites, Horticulture 2 and Pomology 1 and 2. Seniors; 5 hours. Credit, 3. Professor SEARS.

4. COMMERCIAL POMOLOGY. — The storing and marketing of fruits; includes a discussion of storage houses, the handling and storing of fruits, fruit packages, methods of grading and packing, etc. Text and reference books; laboratory exercises. Seniors; prerequisites, Horticulture 2, Pomology 1, 2 and 3; 5 hours. Credit, 3. Professor SEARS.

*Department of Floriculture.**Elective Courses.*

1. GREENHOUSE MANAGEMENT. — This course is designed to familiarize students with methods followed in the management of greenhouse crops. The students are instructed in the practical operation of glazing concrete, bench construction, bulb culture, greenhouse watering, fumigating and ventilating, in the care of furnaces, and in the methods of propagation of greenhouse plants

by seeds, cuttings, budding and grafting. This is designed as a laboratory course, and students electing it will be expected to arrange their hours according to the needs of the work. Prerequisite, Horticulture 2. Juniors; 7 hours a week. Credit, 4.

Professor WHITE.

2. GREENHOUSE DESIGN AND CONSTRUCTION. — A continuation of Course 1, including also a study of the location, arrangement and construction of greenhouses; the drawing of plans for commercial and private ranges, to show foundations and details in construction of superstructure; arrangement of heating pipes; estimates of comparative cost of different methods of construction; drafting specifications. Juniors; prerequisite. Floriculture 1; 7 hours. Credit, 4.

Professor WHITE.

3. FALL GREENHOUSE CROPS. — A study of important fall and winter crops and their care, — chrysanthemums, carnations, violets, roses, palms, and the like; the importation, purchase and growth of bulbous material; the preparation of material for forcing; design making; house and church decorating. Lectures, text-books and laboratory exercises. Prerequisites, Floriculture 1 and 2. Seniors; 5 hours. Credit, 3.

Professor WHITE.

4. SPRING GREENHOUSE CROPS. — The culture of individual crops in their relation to spring work in a florist establishment. A critical study of methods of propagating bedding plants, the nature and use of these plants, practice in planting them and in the spring care of herbaceous perennials and wholesale and retail marketing of spring plants. Lectures, text-books and practical exercises. Seniors; prerequisites, Floriculture 1, 2 and 3; 5 hours. Credit, 3.

Professor WHITE.

Department of Landscape Gardening.

Elective Courses.

1. ELEMENTS OF LANDSCAPE GARDENING. — Reconnaissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected works of leading landscape gardeners; grade design, road design and field work. Students should have preparation in surveying, mathematics, plant materials and drawing. Must be followed by Course 2. Juniors; 7 hours a week. Credit, 4.

Mr. NOYES.

2. ELEMENTS OF LANDSCAPE GARDENING. — As stated under Course 1. Prerequisite, Course 1.

Professor WAUGH and Mr. NOYES.

3. GENERAL LANDSCAPE GARDENING. — Field notes; examination of completed works and those under construction; design of architectural details; planting plans; estimates; written reports of individual problems. Seniors; prerequisites, Landscape Gardening 1 and 2, and either plant materials (Horticulture 3 and 4) or advanced mathematics; must be followed by Course 4; 7 hours. Credit, 4.

Professor WAUGH and Mr. NOYES.

4. GENERAL LANDSCAPE GARDENING. — As stated under Course 3. Prerequisite, Course 3.

Professor WAUGH and Mr. NOYES.

5. THEORY OF LANDSCAPE ART. — The general theory and applications of landscape study, including a brief history of the art. Seniors and graduates; 2 hours. Credit, 2.

Professor WAUGH.

6. ARCHITECTURE. — A course giving the history of architectural development, the different historic types, with special reference to the underlying principles of design and construction and to the applications in landscape architecture. Lectures, illustrated with stereopticon and plates; conferences; practice in design; 2 hours. Credit, 2.

Mr. NOYES.

7. CIVIC ART. — The principles and applications of modern civic art, including city design, city improvement, village improvement and rural improvement. Text-book, Robinson's "Modern Civic Art." Prerequisites, Courses 1, 2 and 3; must be followed by Course 8; 6 hours. Credit, 3.

Professor WAUGH.

8. CIVIC ART. — As stated under Course 7. Prerequisite, Course 7.

Professor WAUGH.

*Department of Forestry.**Elective Courses.*

1. DENDROLOGY AND SILVICULTURE. — These two subjects run parallel throughout the year. Under dendrology, the habits and needs of trees are studied, their distribution, soil and moisture requirements, growth, etc. Under silviculture are taken up the life history of trees and stands; tree characteristics, how modified; the concept of a forest and its subdivisions; methods of reproduction, both natural and artificial, with both theoretical and practical work in thinnings and nursery practice. Juniors; 3 lectures weekly, with 4 additional hours of optional field work. Credit, 3. Associate Professor MOON.

2. DENDROLOGY AND SILVICULTURE. — As stated under Course 1. Prerequisite, Forestry 1. Associate Professor MOON.

*Market Gardening.**Elective Courses.*

2. ELEMENTS OF MARKET GARDENING. — A study of market gardening as a business, with detailed consideration of the conditions under which it is practiced. The problems of soil selection and soil management, garden fertilization and tillage, receive attention from the viewpoint of the market gardener, and considerable time is devoted to the study of garden crops. Juniors; prerequisite, Horticulture 2; 3 hours. Credit, 3. Mr. HELLER.

3. ADVANCED MARKET GARDENING. — A continuation of the work begun in Market Gardening 2, taking up problems of seed growing, selection of varieties, crop management, harvesting, storage and marketing. A study is made of the greenhouse vegetable industry, and considerable time devoted to growing the special forced crops. Some time is given to a systematic study of vegetable description, classification and nomenclature. Collateral reading is required. Floriculture 2 must be taken in connection with this course. Seniors; prerequisite, Market Gardening 2; 5 hours. Credit, 3. Mr. HELLER.

*Drawing.**Elective Courses.*

1. FREEHAND DRAWING. — Lettering; sketching from type models, leaves, fruits, vegetables, flowers and trees, insects and small animals; laying flat and graded washes in water colors; water-color

rendering of fruits, vegetables, leaves, flowers and trees; topographical lettering and conventional signs in ink; conventional coloring; mapping in ink and in water colors. (Was not given in 1909-10.) Juniors; 6 hours. Credit, 3. Mr. NOYES.

2. MECHANICAL DRAWING. — Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Juniors; 6 hours. Credit, 3. Mr. NOYES.

DIVISION OF THE HUMANITIES.

Professor MILLS,¹ Associate Professor NEAL, Assistant Professor EYERLY, Assistant Professor MCKAY, Mr. HOLCOMB, Mr. MACKIMMIE, Mr. ASHLEY, Mr. GREEN, Miss GOESSMANN.

Departments.

ENGLISH.
MODERN EUROPEAN LANGUAGES.
MUSIC (SECTION).
POLITICAL SCIENCE.
LIBRARY.

Department of English.

ENGLISH LANGUAGE; JOURNALISM.
LITERATURE.
PUBLIC SPEAKING.

ENGLISH LANGUAGE.

Required Courses.

1. FRESHMAN ENGLISH.—Composition; introduction to literature. Recitations and lectures; theme writing; conferences.² Freshmen; 4 hours. Credit, 4.

Associate Professor NEAL and Assistant Professor MCKAY.

2. FRESHMAN ENGLISH. — As stated under Course 1. Prerequisite, Course 1; 4 hours. Credit, 4.

Associate Professor NEAL and Assistant Professor MCKAY.

¹ Absent on leave.

² Student assistants (in charge of freshman groups for tutoring in spelling, punctuation and similar elementary matters; theme readers). Class of 1911: Herbert Jonathan Baker (second year); Edgar Morton Brown (second year, semester one); Leonard Matthews Johnson (second year); Bernard Ostrolenk (second year). Class of 1912: Royal Norton Hallowell (semester one), Marshall Cotting Pratt, Lawrence Peck Rockwood, Lewis Raymond Sellow (second semester).

3. SOPHOMORE ENGLISH.¹ — Composition; literature. Prerequisite, Course 2; sophomores; 2 hours. Credit, 2.

Associate Professor NEAL.

4. SOPHOMORE ENGLISH.¹ — As stated under Course 3. Prerequisite, Course 3.

Assistant Professor MCKAY and Miss GOESSMANN.

7. TRAINING COURSE. — A course (a) required of student assistants in English, and (b) open (with the instructor's consent) to candidates for a tutorship. Candidates are expected to take it in qualifying for appointment. The course may be taken for either sophomore or elective credit. Two hours. Credit, 2.

Associate Professor NEAL.

8. TRAINING COURSE. — As outlined under Course 7.

Associate Professor NEAL.

A. *Use of Library.* — Lectures on the use of the Library. Hours to be appointed. Required of all sophomores in the first semester as part of Course 3.

Mr. GREEN.

[Enrolment in the elective courses in the Department of English is subject to the approval of the instructor. The membership in several of the courses is strictly limited; hence students are advised to plan their work well in advance in order to be sure of completing the required three hours of post-sophomore English. This credit must be made up without taking Literature 15 or 16.]

ENGLISH LANGUAGE AND JOURNALISM.

Elective Courses.

9. JOURNALISM.² — Under the title "Journalism" are grouped agricultural journalism, newspaper and periodical writing and a somewhat more advanced study of journals and journalistic writing. All these courses are closely related. In the beginning, the course in agricultural journalism and that in periodical writing are identical; the introductory work in periodical writing — such

¹ Students whose work in Courses 1 and 2 reaches a standard satisfactory to the Department may be excused from not more than half of the sophomore work in English. At present, students in Course 3 or Course 4 are permitted, under restrictions to be stated by the Department, to substitute Public Speaking for English Language and Literature.

² The attention of students who elect courses in Journalism is specially directed to the courses given in the collateral subjects here mentioned: Agricultural Education, especially Courses 1 (Psychology) and 2; French; German; Spanish; Political Science; Rural Social Science; English Language and Literature; Public Speaking. By judicious election among the scientific courses and among courses in the subjects named above, a student wishing to follow either agricultural or general journalism can broadly and effectively prepare himself for the profession.

as desk editing, proof reading, and especially the writing of news stories in simple reporting style — being deemed necessary as training preparatory to any kind of journalistic work. The chief differences between the courses are, (1) that Course 9A (agricultural) opens more immediate opportunities for practical work, as publication for a limited amount of the student writing is found in agricultural periodicals; and (2) that Course 9B (periodical) opens the way for more varied observation and investigation, and for more varied experience in writing, contributing in these ways to general culture, as Course 9A contributes to specialized training. In addition, the course in periodical writing has in mind the increasing importance of rural journalism as an influence and occupation in the developed rural community.

A. Agricultural Journalism. — The production of “copy” adapted to the use of agricultural periodicals. The class, organized as an editorial staff, is charged with the preparation of an agricultural periodical. Two hours. Credit, 2.

B. Newspaper and Periodical Writing. — The elements of journalism — newspaper and magazine writing, reporting, editing, printing, etc. The class, organized as an editorial staff, is to issue a periodical. It is responsible for “covering” events, desk editing, copy and proof reading, making “dummies” and writing legends for illustrations, completing “forms” and “publishing” the periodical upon schedule time, etc. The first semester will be devoted principally to newspaper writing; the second semester to periodical writing. Two hours. Credit, 2.

[C. Proseminar in Journalism. — Informal, beginning with a study by individual students of editorial writing and of types of magazine writing, such as “descriptive” articles, research articles, “human interest” articles, and articles in “popularized” science. Members of the class are expected to formulate through these studies theories of journalism and journalistic writing, to state them in thesis form, and to produce articles of the kinds studied. Reference reading and reports upon current periodicals may be called for. Given only by special arrangement. One hour. Credit, 1.]

9A and 9B may be taken at the same time.

Associate Professor NEAL.

10. JOURNALISM. — As stated under Course 9.

Associate Professor NEAL.

15. ENGLISH LANGUAGE. — See Literature 15.

16. ENGLISH LANGUAGE. — See Literature 16.

[17. ADVANCED COMPOSITION. — A course varying in plan, but usually concerned with some form of exposition, description or narration. Not given in 1910-11. Two hours. Credit, 2.

Associate Professor NEAL.]

LITERATURE.

Required Courses.

1, 2, 3, 4, 7 and 8. — See the courses so numbered under "English Language."

Elective Courses.

9. CULTURAL READING.¹ — Individual reading courses intended to encourage broader acquaintance with (a) literature, (b) art, (c) philosophy (including psychology), or (d) history (including political and social science). The reading must be sufficient to require forty-five hours; must be entirely non-technical; may be in any of the subjects indicated above; must not consist in research; and may — subject strictly to its purpose — be taken in any department by arrangement between the student and the instructor in the department concerned. If the reading be taken outside the Department of English, the student must present in writing the consent of the instructor under whom he wishes to read. Each student must present a two-thousand-word paper and a notebook. Prerequisite, the sophomore courses in English; total credits allowed to one student for cultural reading work, 2. Credit, 1.

Associate Professor NEAL.

10. CULTURAL READING. — As stated under Course 9.

Associate Professor NEAL.

13. LITERARY HISTORY. — A course dealing with literary periods or with authors; in 1910-11, Elizabethan literature. Lectures, text-book and reference assignments, and class-room interpretation of authors; much outside reading; written studies upon

¹ Courses in semester one include: Poe, Kipling, Stevenson, English fiction in the nineteenth Century, Carlyle, American prose, Wordsworth, Tennyson, psychology, evolution; and, outside the Department of English, biography of great chemists, political science, and landscape art.

announcement. Given upon application. Prerequisite, the sophomore courses in English. Two hours. Credit, 2.

Associate Professor NEAL.

14. LITERARY HISTORY. — As outlined under Course 13. In 1910-11, Tennyson.

Associate Professor NEAL.

[15. ENGLISH LANGUAGE AND LITERATURE. — The origin, history and development of the English language; essayists and novelists of the nineteenth century. Continuous with Course 16. Not given in 1910-11. Seniors; 3 hours. Credit, 3.

Professor MILLS.]

[16. ENGLISH LANGUAGE AND LITERATURE. — Continuous with Course 15. The elements of literary criticism; nineteenth century poets. Not given in 1910-11. Seniors; 3 hours. Credit, 3.

Professor MILLS.]

18. ADVANCED LITERATURE. — This course varies from year to year. It will usually provide opportunity either for intensive study of great writers or for study of the historical development or the structure and characteristic of literary types; in 1910-11, the English novel. Open only upon arrangement. Tests and examinations. Two hours, with a third hour at the option of the instructor. Credit, 2.

Associate Professor NEAL.

PUBLIC SPEAKING.

Required Courses.

1. FRESHMAN PUBLIC SPEAKING. — Freshman public speaking is required in either the first or the second semester, at the option of the instructor. Voice exercises; practice in the delivery of declamations and interpretive readings. Freshmen; 1 hour. Credit, 1.

Assistant Professor MCKAY.

2. FRESHMAN PUBLIC SPEAKING. — As stated under Course 1. Required of all freshmen who are not assigned to take Course 1.

Assistant Professor MCKAY.

3. SOPHOMORE PUBLIC SPEAKING. — Original speeches on assigned topics and declamations, supplemented by exercises in voice development and gesture. Elective within the English Depart-

ment, as stated under English Language 3. Prerequisite, Course 1 or 2, or its equivalent. Sophomores; 1 hour. Credit, 1.

Assistant Professor MCKAY.

4. SOPHOMORE PUBLIC SPEAKING. — Work of the same character as in Course 3, but more advanced. This course offers practice in the making of longer original speeches, in declamation, debating and dramatic reading. Elective within the English Department, as stated under English Language 3. Prerequisite, Course 3. Sophomores; 1 hour. Credit, 1.

Assistant Professor MCKAY.

Elective Courses.

8. ORATORY. — Speeches on assigned topics; prescribed reading; the preparation and delivery of an oration, supplemented by a study of the principles of oratorical composition and delivery. It is especially recommended for those who desire to enter the Flint contest. Prerequisite, Course 3; 1 hour. Credit, 1.

Assistant Professor MCKAY.

9. DEBATING. — Considerable time is given to the study of argumentation and brief-drawing. The class is divided into teams for the platform discussion of leading questions of the day. This course is designed to develop readiness in extempore speaking. It is recommended for those who desire to enter the intercollegiate debates. Prerequisite, Course 3; 2 hours. Credit, 2.

Assistant Professor MCKAY.

10. DRAMATIC READING. — Exercises for voice and gesture; a study of the elements of vocal expression and action; expressional reading of selections in prose and poetry; presentation of scenes from plays. Prerequisite, Course 3; 1 hour. Credit, 1.

Assistant Professor MCKAY.

Department of Modern European Languages.

FRENCH.

Required Courses.

1. ELEMENTARY FRENCH. — A beginning course. Fraser & Squair's "French Grammar;" reader; graduated texts. Required of freshmen presenting German for entrance who do not continue that language and have not studied French; open upon arrangement to other students. Freshmen; 4 hours. Credit, 4.

MR. MACKIMMIE.

2. ELEMENTARY FRENCH. — As stated under Course 1. Prerequisite, Course 1. Mr. MACKIMMIE.

3. INTERMEDIATE FRENCH (third year). — Training for rapid reading; the reading of a number of standard novels and plays; composition; reports on collateral reading from periodicals and scientific texts in the library. Required of freshmen who present two years of French for entrance and do not take German, and of sophomores who take Courses 1 and 2 as freshmen; open upon arrangement to other students; 4 hours. Credit, 4.

Mr. MACKIMMIE.

4. INTERMEDIATE FRENCH. — As stated under Course 3, but not required of sophomores who take Courses 1 and 2 as freshmen. Prerequisite, Course 3. Mr. MACKIMMIE.

5. ADVANCED FRENCH (fourth year). — A reading course; representative masterpieces of the nineteenth century; collateral reading and written reports. Required of sophomores who take Courses 3 and 4 as freshmen; open upon arrangement to other students. Prerequisite, Course 4; 3 hours. Credit, 3.

Mr. MACKIMMIE.

Elective Courses.

6. ADVANCED FRENCH (fourth year). — A general view of the history of French literature. Several plays of the great classical dramatists will be read. Prerequisite, Course 5. Sophomores; open upon arrangement to other students; 3 hours. Credit, 3.

Mr. MACKIMMIE.

7. FRENCH LANGUAGE OR LITERATURE (fourth year). — Courses in more advanced subjects; to be announced; 3 hours. Credit, 3.

Mr. MACKIMMIE.

8. FRENCH LANGUAGE OR LITERATURE. — As outlined under Course 7. Mr. MACKIMMIE.

SPANISH.

Elective Courses.

1. ELEMENTARY SPANISH. — Grammar, with special drill in pronunciation; reading from a simple reader. Seniors; open upon arrangement to other students; 4 hours. Credit, 4.

Mr. MACKIMMIE.

2. MODERN SPANISH AUTHORS.—Reading from modern Spanish novel and drama. Prerequisite, Course 1. Seniors; open upon arrangement to other students; 4 hours. Credit, 4.

Mr. MACKIMMIE.

GERMAN.

Required Courses.

1. ELEMENTARY GERMAN.—Grammar and composition; the reading of short stories, poems, plays, etc. Especial attention is given to oral questioning and answering in German, and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4.

Mr. ASHLEY.

2. ELEMENTARY GERMAN.—As stated under Course 1. Prerequisite, Course 1.

Mr. ASHLEY.

3. INTERMEDIATE GERMAN.—Rapid reading of selected works from Schiller, Goethe, Lessing and others; review of grammar and dictation in German; outside readings. Required of freshmen who present German for entrance and do not take French. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4.

Mr. ASHLEY.

3A. INTERMEDIATE GERMAN.—Rapid reading of prose works, such as Sudermann's "Frau Sorge," and dramas, such as "Wilhelm Tell" and "Die Journalisten." Required of sophomores who took Courses 1 and 2 as freshmen.

Mr. ASHLEY.

4. INTERMEDIATE GERMAN.—As stated under Course 3. Prerequisite, Course 3.

Mr. ASHLEY.

4A. INTERMEDIATE GERMAN.—As stated under Course 3A. Open to students who have completed German 3A; 3 hours. Credit, 3.

Mr. ASHLEY.

5. ADVANCED GERMAN.—Literary study of the classicists,—Schiller's "Wallenstein," Lessing's "Nathan der Weise," Goethe's "Iphigenia," etc.; collateral readings in German and class-room reports. Conducted in German. Prerequisite, Course 4. Sophomores; required of those who took German 3 and 4 as freshmen; open upon arrangement to other students; 3 hours. Credit, 3.

Mr. ASHLEY.

Elective Courses.

6. ADVANCED GERMAN. — As stated under Course 5. Sophomores; open upon arrangement to other students. Prerequisite, Course 5; 3 hours. Credit, 3. Mr. ASHLEY.

7. MODERN GERMAN. — Reading of articles from the best modern German periodicals, such as "Ueber Land und Meer;" conversation and composition work based on text. "Ferien in Deutschland," prepared by instructor; 3 hours. Credit, 3. Mr. ASHLEY.

8. MODERN GERMAN. — As stated under Course 7.

Mr. ASHLEY.

*Music.**Elective Courses.*

1. HISTORY AND INTERPRETATION OF MUSIC. — History of music among the ancients; medieval religious and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school — Bach, Händel, Haydn, Gluck and Mozart. One hour. Credit, 1. Mr. ASHLEY.

2. HISTORY AND INTERPRETATION OF MUSIC. — A continuation of Course 1. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera. The Modern school and Modern composers. One hour. Credit, 1. Mr. ASHLEY.

*Department of Political Science.**Required Courses.*

1. ECONOMICS. — An introductory course. A study of the nature and scope of economics; the evolution and organization of the present economic system; and the principles of consumption, production, exchange and distribution. Text-books, lectures and essays; required, but may be taken in either the junior or the senior year; 3 hours. Credit, 3. Assistant Professor EYERLY.

Elective Courses.

2. GOVERNMENT. — The organization and working of the various kinds of government in the United States; government problems connected with transportation, taxation and monopolies;

comparison of State leadership in American agriculture with that in European agriculture. Text-books, lectures and assigned reading; 3 hours. Credit, 3. Assistant Professor EYERLY.

3. SOCIOLOGY. — The nature, scope and principles of sociology; social origins and structures; control by custom, religion, education, public opinion, law, etc.; social ideals; practical problems in social progress. Lectures, text-book and assigned readings; 3 hours. Credit, 3. Assistant Professor EYERLY.

4. ECONOMIC HISTORY. — The economic history of England to the reign of Henry VIII.; the history of England and the American colonies in conjunction to 1783; and thereafter the history of England and of the United States. Emphasis is laid on economic history, but the more important political and religious movements are treated in their economic relations. Text-books, lectures and assigned reading; 3 hours. Credit, 3.

Assistant Professor EYERLY.

5. THE HISTORY OF NEW ENGLAND. — In this course, New England is regarded as a unit. Although the history of agriculture and rural life is treated with special fulness, ample attention is given to political, religious and ethical history. It is hoped that the student will not only be led to an intelligent understanding of present economic conditions, but will also be imbued with a progressive loyalty to the highest ideals of the New England of the past. Lectures and required reading; 3 hours. Credit, 3.

MR. HOLCOMB.

6. PRACTICAL PROBLEMS IN ECONOMICS. — An advanced course following Economics 1. A group of problems will be selected for careful study. Each student will make a special study of one of the following topics: labor, capital, money, banking, insurance, protection and free trade, railways, corporations, and the personal distribution of wealth. Lectures, assigned readings and reports; 3 hours. Credit, 3. Assistant Professor EYERLY.

8. THE HISTORY OF IDEALS. — This course treats history from the idealistic, rather than from the economic, point of view. It attempts to define the great ideals which have impelled some of the most important social, political, esthetic, scientific, ethical and religious movements of medieval and modern history, and to trace the

causes of the success or failure of the movements to which these ideals have led. Christianity, including monasticism, modern Catholicism and Protestantism; medieval art and architecture; the modern scientific movement; and social and political democracy will be treated historically from this point of view. Lectures and reading; 3 hours. Credit, 3. Mr. HOLCOMB.

Department of Mathematics, Physics and Civil Engineering.

Professor OSTRANDER, Associate Professor HASBROUCK, Captain MARTIN,
Mr. DUNCAN.

Required Courses.

1. HIGHER ALGEBRA. — A brief review of radicals, quadratic equations, ratio and proportion, and progressions; binomial theorem, undetermined coefficients, summation of series, continued fractions, logarithms, theory of equations. Wells's "College Algebra." Freshmen; 5 hours a week. Credit, 5.

Associate Professor HASBROUCK, Captain MARTIN
and Mr. DUNCAN.

2. SOLID GEOMETRY. — Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Gore's "Solid Geometry." Freshmen; required unless accepted for admission; 2 hours. Credit, 2. Mr. DUNCAN.

4. PLANE TRIGONOMETRY. — The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry." Required unless accepted for admission. Freshmen; 3 hours. Credit, 3.

Associate Professor HASBROUCK, Captain MARTIN.

5. GENERAL PHYSICS. — Elementary mechanics and heat. Lectures, recitations and laboratory work. Text-book and lectures. Sophomores; 4 hours class-room work and 1 laboratory period. Credit, 5. Adjunct Professor HASBROUCK and Mr. DUNCAN.

Elective Courses.

6. GENERAL PHYSICS. — Electricity and light. Text-book, lectures, recitations and laboratory work. Sophomores; 2 hours of class-room work and 1 laboratory period. Credit, 3.

Adjunct Professor HASBROUCK and Mr. DUNCAN.

[9. ADVANCED PHYSICS. — The senior elective in physics is not offered for the year 1910–11.

Adjunct Professor HASBROUCK.]

8. PLANE SURVEYING. — The elements of the subject, including the adjustment and use of the usual instruments. Text-book and lectures. Sophomores; 6 hours a week. Credit, 3.

Mr. DUNCAN.

7. ANALYTIC GEOMETRY. — A discussion of the geometry of the line, the circle, of conic sections and of the higher plane curves. Fine and Thompson's "Coördinate Geometry." Prerequisites, Mathematics 1, 2 and 4; 3 hours a week. Credit, 3.

Professor OSTRANDER.

10. DIFFERENTIAL AND INTEGRAL CALCULUS. — A first course in the subject, with some of the more important applications. Granville and Smith's "Differential and Integral Calculus." Prerequisites, Mathematics 1, 2, 4 and 7; 5 hours. Credit, 5.

Professor OSTRANDER.

[11. HYDRAULICS AND SANITARY ENGINEERING.¹ — Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. Text-book and lectures; 3 hours. Not given in 1910–11. Credit, 3.

Professor OSTRANDER.]

[12. ADVANCED SURVEYING.¹ — Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. Text-book and lectures; 6 hours. Not given in 1910–11. Credit, 5.

Professor OSTRANDER.]

13. STRESSES IN STRUCTURES.¹ — An elementary course in roof

¹ Instruction in civil engineering will be given in two distinct courses of one year each, the courses alternating. The courses are open to students of the junior and senior classes.

and bridge stresses. Text-book and lectures; 4 hours. Not given in 1911-12. Credit, 3. Professor OSTRANDER.

14. STRENGTH OF MATERIALS, FOUNDATIONS AND MASONRY CONSTRUCTION.¹— Text-book and lectures; 6 hours. Not given in 1911-12. Credit, 5. Professor OSTRANDER.

15. ANALYTIC MECHANICS.— A course in theoretical mechanics, based on the calculus, with applications to problems. Text-book and lectures. Prerequisites, Mathematics 7, 10; 3 hours. Credit, 3. Professor OSTRANDER.

Department of Military Science and Tactics.

Captain MARTIN.

[The Department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement:—

All candidates for a degree in a four-years course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical (drill) courses in Military Science are given up to the Christmas recess and from the close of the spring recess to the end of the semester each year; the corresponding courses in Physical Education occupy the intervening time.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offences of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor. Practice in the band is credited in place of drill and theoretical instruction.

A dark blue uniform, old army pattern, costing about \$15, is worn by all cadets when on military duty, and may be worn at other times. The uniforms are procured through an authorized tailor. Students upon entering college are required to deposit \$15 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited, unless the consent of the military instructor be obtained.]

Required Courses.

1. INTRODUCTION TO MILITARY SCIENCE AND TACTICS.— Practical instruction in infantry drill regulations through the school of the battalion in close and extended order; advance and rear guards;

outposts; marches; ceremonies; guard duty. Upon the conduct and proficiency of this year depends the appointment of corporals for the ensuing year. Freshmen; first semester until Christmas recess; 3 hours. Credit, 1. Captain MARTIN.

2. INTRODUCTION TO MILITARY SCIENCE AND TACTICS.—As stated under Course 1. Freshmen; second semester after spring recess; 3 hours. Credit, 1. Captain MARTIN.

3. PRACTICE OF MILITARY SCIENCE AND TACTICS.—Practical instruction as before; pointing, aiming and sighting drills; litter drills, and first aid to the injured by detachment; target practice, in gallery and on the range. Corporals are appointed from this class. On their conduct and proficiency depends the appointment of sergeants in the next class. Sophomores; first semester until Christmas recess; 3 hours. Credit, 1. Captain MARTIN.

4. PRACTICE OF MILITARY SCIENCE AND TACTICS.—As stated under Course 3. Sophomores; second semester after spring recess; 3 hours. Credit, 1. Captain MARTIN.

5. THEORY OF MILITARY SCIENCE AND TACTICS.—Theoretical instruction in "Infantry Drill Regulations," to include the school of the company, "Manual of Guard Duty," "Small Arms Firing Regulations." Sophomores; 1 hour. Credit, 1. Captain MARTIN.

6. THEORY OF MILITARY SCIENCE AND TACTICS.—As stated under Course 5. Sophomores; 1 hour. Credit, 1. Captain MARTIN.

7. PRACTICE OF HIGHER MILITARY SCIENCE AND TACTICS.—Practical instruction as before, target practice, in gallery and on the range. Sergeants are appointed from this class. On their conduct and proficiency depends their selection as officers for the ensuing year. When necessary, officers will also be appointed from this class. Juniors; first semester until Christmas recess; 3 hours. Credit, 1. Captain MARTIN.

8. PRACTICE OF HIGHER MILITARY SCIENCE AND TACTICS.—As stated under Course 7. Juniors; second semester after spring recess; 3 hours. Credit, 1. Captain MARTIN.

9. THEORY OF HIGHER MILITARY SCIENCE AND TACTICS. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the battalion; advance and rear guards; outposts; marches and ceremonies; "Manual of Field Service Regulations;" preparation of reports, returns, muster-rolls, enlistment and discharge papers, rosters, requisitions, etc.; army regulations; lectures on military science. Juniors; 1 hour. Credit, 1.
Captain MARTIN.

10. THEORY OF HIGHER MILITARY SCIENCE AND TACTICS. — As stated under Course 9. Juniors; 1 hour. Credit, 1.
Captain MARTIN.

Elective Courses.

11. ADVANCED MILITARY SCIENCE AND TACTICS. — Practical instruction as before; conduct of drills of lower classes. Officers will as a rule be selected from this class. Cadets electing Courses 11 and 12 must make the election for the year, and not later than the first Monday in June of their junior year. No cadet electing this course will after the commencement drill be permitted to change his election without the consent of the dean of the faculty and of the commandant. Seniors; first semester until Christmas recess; 3 hours. Credit, 1.
Captain MARTIN.

12. ADVANCED MILITARY SCIENCE AND TACTICS. — As stated under Course 11. Seniors; second semester after spring recess; 3 hours. Credit, 1.
Captain MARTIN.

Department of Physical Education and Hygiene.

Assistant Professor REYNOLDS.

HYGIENE.

Required Courses.

1. HYGIENE. — Lectures, reading, quizzes and a report on some assigned topic of personal hygiene or sanitation. Freshmen; 1 hour. Credit, 1.
Assistant Professor REYNOLDS.

PHYSICAL EDUCATION.

[The Department of Physical Education conducts its work in physical training in conjunction with the Department of Military Science and Tactics, as explained in the note preceding the description of the courses in Military Science. All classified undergraduate students are given a physical examination upon entering.]

Required Courses.

1. ELEMENTARY GYMNASTICS. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 2. Freshmen; 3 hours. Credit, 1.
Assistant Professor REYNOLDS.

2. ELEMENTARY GYMNASTICS. — As stated under Course 1.
Assistant Professor REYNOLDS.

3. GRADED GYMNASTICS. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 4. Sophomores; 3 hours. Credit, 1.
Assistant Professor REYNOLDS.

4. GRADED GYMNASTICS. — As stated under Course 3.
Assistant Professor REYNOLDS.

5. HEAVY GYMNASTICS. — Drills, games and athletics; from January 1 to April 1, in connection with Course 6. Juniors; 3 hours. Credit, 1.
Assistant Professor REYNOLDS.

6. HEAVY GYMNASTICS. — As stated under Course 5.
Assistant Professor REYNOLDS.

Elective Courses.

7. TRAINING COURSE. — Leadership class and squad work; supervision of indoor and outdoor athletic contests and games; boxing and wrestling. Seniors; 3 hours. Credit, 1.
Assistant Professor REYNOLDS.

8. TRAINING COURSE. — As stated under Course 7.
Assistant Professor REYNOLDS.

9. ADVANCED GYMNASTICS. — For those who wish to become candidates for the gymnastic team. Credit, 0.
Assistant Professor REYNOLDS.

10. ADVANCED GYMNASTICS. — As stated under Course 9.
Assistant Professor REYNOLDS.

Department of Rural Social Science.

President BUTTERFIELD, Assistant Professor EYERLY, Assistant Professor CANCE.

AGRICULTURAL ECONOMICS.

Required Courses.

2. AGRICULTURAL INDUSTRY AND RESOURCES. — A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers'

demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions. Sophomores; 3 hours. Credit, 3. Assistant Professor CANCE.

Elective Courses.

4. ELEMENTS OF AGRICULTURAL ECONOMICS. — This course is designed to follow the required work in the elements of economics. It will consider the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; the agricultural market; determination of price; speculation; problems of land tenure and land values; business co-operation; farmers' organizations; the farmer and legislation; the maintenance of the social, political and economic status of the farmer; and the relation of the farmer to the State. Lectures, text, readings, topics and field work; 3 hours. Credit, 3.

Assistant Professor CANCE.

5. HISTORICAL AND COMPARATIVE AGRICULTURE. — A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on present conditions and the history of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, to show that the agriculture of any country is a distinct individual problem, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work. Seniors; open to other students upon arrangement; prerequisite, Course 4 or equivalent; 3 hours. Credit, 3. Assistant Professor CANCE.

6. CO-OPERATION IN AGRICULTURE. — The course contemplates a somewhat comprehensive view of the history, principles and social relations of agricultural organization for profit. Part I., The business aspects of co-operation: (1) A survey of the development and progress, the methods and economic results, of the farmers' organizations and great co-operative movements in the past; (2) the phases of business organization of agriculture abroad, and the

present aspects and tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers, and practical working plans for co-operative associations, as illustrated by the most advanced and prosperous business organizations and exchanges, with particular reference to the marketing of perishable products. Part II., Social aspects of co-operation: The second part of this course treats of the social conditions necessary to successful co-operation; the effect of co-operation on character, *e.g.*, on individualism, conservatism; the relation of co-operation to political achievement, especially as illustrated in European countries; the influence of co-operation in begetting a community consciousness; and the effect of organization on class status. Lectures, assigned reading and practical exercises; 3 hours. Credit, 3.

Assistant Professor CANCE (Part I.)

Assistant Professor EYERLY (Part II.).

7. SPECIFIC PROBLEMS IN AGRICULTURAL ECONOMICS.—An advanced course for students desirous of studying more intensively some of the problems immediately affecting the welfare of the farmer and society. Some of the problems that may be studied are: land problems; land tenure; size of farms; causes affecting land values; private property in land; taxation and inheritance; special problems; marketing and manufacturing farm products; cost of production; farm labor in New England; immigration; shifting of the rural population. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest. Seniors; open upon arrangement to other students; enrollment subject to approval of instructor; 2 hours a week. Credit, 2.

Assistant Professor CANCE.

9. SEMINAR.—Research in agriculture: New England agriculture to 1860. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged. Credit, 1.

Assistant Professor CANCE.

10. SEMINAR.—As stated in Course 9.

Assistant Professor CANCE.

RURAL SOCIOLOGY.

Elective Courses.

12. THE RURAL COMMUNITY. — There are two general divisions of the subject. There is, first, a study of the social status of the rural population, including the significance of the movement to the cities, the present social conditions of farm people, the social effects of rural life, and the social aspect of various agricultural questions of a technical or economic character. In the second part of the study will be discussed the various social agencies in rural progress, such as means of communication, farmers' organizations, rural schools, means of agricultural education, rural religious institutions and the federation of rural social agencies. Lectures, readings and essays on assigned topics; 3 hours. Credit, 3.

President BUTTERFIELD and Assistant Professor EYERLY.

16. RURAL LITERATURE. — A critical and appreciative study of writers, both in prose and poetry, who have interpreted Nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities; 3 hours. Credit, 3.

Mr. HOLCOMB.

Department of Veterinary Science.

Professor PAIGE.

[The courses in veterinary science have been arranged to meet the needs of students who purpose following practical agriculture, and of prospective students of human and comparative medicine.]

Elective Courses.

1. INTRODUCTORY BACTERIOLOGY. — The object of this course is to acquaint the student with the various organisms found in air, water, soil, milk and the body, and with the relation of these organisms to such processes as decomposition, fermentation and digestion, and to the production of disease. Toxic substances resulting from the growth of organisms, and the antitoxins used to counteract their action, are considered. Lectures, recitations and laboratory work. Seniors; 3 two-hour laboratory exercises. Credit, 3.

Professor PAIGE.

3. VETERINARY SCIENCE. — A course treating of veterinary hygiene, comparative anatomy and general pathology; veterinary materia medica and therapeutics; the theory and practice of

veterinary medicine; general, special and operative surgery; and veterinary bacteriology and parasitology. Lectures, clinics, demonstrations and laboratory exercises. Must be followed by Course 4. Seniors; 5 hours. Credit, 5. Professor PAIGE.

4. VETERINARY SCIENCE. — As stated under Course 3.

Professor PAIGE.

Department of Zoölogy and Geology.

Assistant Professor GORDON.

ZOÖLOGY.

Required Courses.

1. ELEMENTARY ZOÖLOGY. — This course in a general way constitutes the zoölogical part of an introductory course in biology. Laboratory dissection and lectures; laboratory text, Drew's "Invertebrate Zoölogy." Sophomores; 2 two-hour laboratory periods and 1 lecture hour. Credit, 3. Assistant Professor GORDON.

Elective Courses.

3. INVERTEBRATE ZOÖLOGY. — This course does not include the insects. Economic zoölogy. Text-books, Parker & Haswell's "Textbook of Zoölogy," Vol. I., and Drew's "Invertebrate Zoölogy." Prerequisite, Course 1 or its equivalent. Must be followed by Course 4. Juniors; 2 two-hour laboratory periods and 1 lecture hour. Credit, 3. Assistant Professor GORDON.

4. VERTEBRATE ZOÖLOGY. — Text-book, Parker & Haswell's "Textbook of Zoölogy," Vol. II. Prerequisite, Course 3. Juniors; 2 two-hour laboratory periods and 1 lecture hour. Credit, 3.

Assistant Professor GORDON.

5. ANIMAL PARASITES. — A survey of this special field of zoölogy. Laboratory and lecture work, with outside reading. Laboratory technique. Seniors; not open to fewer than 3 students. Prerequisites, Courses 1, 3 and 4. Three two-hour periods, 2 one-hour periods. Credit, 5. Assistant Professor GORDON.

6. ANIMAL PARASITES. — A continuation of Course 5. Two two-hour periods, 1 one-hour period. Credit, 3.

7, 8 and 9. ADVANCED ZOÖLOGY. — See "Graduate School."

Assistant Professor GORDON.

GEOLOGY.

Elective Courses.

2. GENERAL GEOLOGY. — Rock-forming minerals; rock types; dynamical, structural and surface geology. Lectures, map and field work. Sophomores; 1 two-hour laboratory period and 2 lecture periods. Credit, 3. Assistant Professor GORDON.

THE GRADUATE SCHOOL.

THE GRADUATE SCHOOL.

KENYON L. BUTTERFIELD, A.M., LL.D., President of the College.

HENRY T. FERNALD, Ph.D., Acting Director of the Graduate School and Professor of Entomology.

Graduate courses leading to the degrees of master of science and doctor of philosophy have been given for a number of years. Demands for these courses have now greatly increased, and in recognition of the benefits to be derived from a separate organization, a distinct graduate school has been established for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment-station agriculturists, bacteriologists, botanists, chemists, entomologists, horticulturists and zoölogists; and for numerous other positions requiring a great degree of skill and scientific knowledge.

ADMISSION.

Admission to the graduate school will be granted:—

1. To graduates of the Massachusetts Agricultural College.
2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the professor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree,—students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for admission to the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and

of the amount and kind of work already done by him as an undergraduate should be submitted, — together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

NATURE AND METHODS OF GRADUATE WORK.

Persons taking graduate work will find this quite different in its nature from undergraduate courses. A broad knowledge of two (or three) subjects is required, and the professors in charge of these may adopt any methods which may seem desirable to secure this to the student. Lectures, laboratory and field work in various forms are utilized; but whatever the method chosen, the aim is to train the students in methods of original investigation and experiment, inductive reasoning and the ability to carry on independent research. In addition to the lectures, a large amount of outside reading is required, the object being to give a broad knowledge of all aspects of the subjects chosen, in addition to the complete knowledge of those portions involved in or directly related to the original investigation which is to result in the thesis. Originality and ability to lead in scientific research after completing graduate work, and the establishment of a broad and thorough foundation upon which these qualities must be based, are the objects aimed at; and any methods which promise to give these results may be made use of (varying according to the nature and personal equation of each student), the supervision being largely individual rather than collective.

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as the major and the other as the minor. These subjects may not be selected in the same department.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major, the others as minors. No two of these subjects may be taken in the same department.

Advanced students who are not candidates for degrees may, with the approval of the faculty of the school, take more than one subject in the same department.

A statement of the subjects chosen must in each case be submitted to the director of the school for approval by the necessary committee. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

A description of the equipment of the various departments is given under "General Information."

THESES.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject, must show that its writer possesses the ability to carry on original research, and must be an actual contribution to knowledge.

The thesis in its final form, ready for the printer, must be submitted to the director of the school for examination by the committee on the graduate school before the candidate for the degree may take the required oral examination. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in the thesis.

All theses become the property of the department in which they are prepared. When they are printed, five copies of each thesis must be deposited with the department.

FINAL EXAMINATIONS.

For the degree of master of science, a final examination, which may be either written or oral, or both, is given upon the completion of each subject.

For the degree of doctor of philosophy, final examinations on the minors taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

DEGREES CONFERRED.

The degree of master of science is conferred upon graduate students who have met the following requirements:—

1. The devotion of at least one year and a half to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence.

2. The devotion of twenty hours each week to the chief or major subject, and of from twelve to sixteen hours per week to the minor subject.

3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.

4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the professors in charge.

5. The payment of all fees and college expenses required.

The degree of doctor of philosophy is conferred upon graduate students who have met the following requirements:—

1. The devotion of at least three years to the prosecution of three subjects of study and research in residence at the college.

2. The devotion of twenty hours each week to the chief or major subject during the entire period, and of from twelve to sixteen hours per week for a year and a half to each minor subject.

3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.

4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the professors in charge.

5. The payment of all fees and college expenses required.

The fee for the degree of master of science is \$10, and for the degree of doctor of philosophy, \$25.

COURSES FOR DEGREE OF MASTER OF SCIENCE.

Available either as major or minor subjects for the degree of master of science:—

Agriculture.

Botany.

Chemistry.

Entomology.

Horticulture.

Mathematics and physics.

Veterinary science.

COURSES FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Available for a major subject for the degree of doctor of philosophy:—

Botany.

Chemistry.

Entomology.

Horticulture.

Available for a minor subject for the degree of doctor of philosophy:—

Agriculture.

Botany.

Chemistry.

Entomology.

Horticulture.

Zoölogy.

GENERAL OUTLINE OF COURSES FOR THE DOCTORATE.

(a) Major Courses.

BOTANY. — The following subjects in botany may be studied: —

- (a) Vegetable physiology.
- (b) Vegetable pathology.
- (c) Mycology.
- (d) Ecology.
- (e) Taxonomy.
- (f) Phylogeny.
- (g) History of botany.
- (h) History and theory of evolution.

These subjects are pursued, to a greater or less extent, as the previous training of the student and the nature of the original problem undertaken may determine. The object of the course is to give the student a technical training in botany, to develop the spirit of research and to lay a broad foundation in the subject. (As a supplement to this course the student will do well to take, in addition to his prescribed minor work, a brief course in the history of philosophy and psychology.) Extensive reading of botanical literature, both general and specific, is required in certain subjects, and occasional lectures are given. A botanical conference is held monthly, in which various new problems of botanical science are considered by graduate students and the seniors who elect botany. A thesis dealing with some economic problem in plant physiology or pathology, or in both, and containing a distinct contribution to knowledge, is required.

CHEMISTRY. — The following subjects in chemistry may be studied: —

- (a) Inorganic analysis, qualitative (of the rarer elements) and quantitative.
- (b) Crystallography.
- (c) Physical chemistry.
- (d) Descriptive and determinative mineralogy.
- (e) Chemical geology.
- (f) Soil formation.
- (g) Soil physics and chemistry; gas analysis; synthetic inorganic work.
- (h) Chemical theory and history.
- (i) General organic chemistry.
- (j) Special topics in organic chemistry.

- (k) Elementary quantitative organic analysis.
- (l) Proximate qualitative and quantitative organic analysis, including determination of organic radicles.
- (m) Organic synthesis of aliphatic and aromatic compounds.
- (n) Problems in chemical manufacture.
- (o) Recent chemistry of plant nutrition.
- (p) Animal physiological and pathological chemistry, including the chemistry of foods, of milk and milk industries, of urine, urinalysis, and the standards for feeding of all kinds.
- (q) Toxicology.
- (r) Insecticides and fungicides.

Frequent examinations on current chemical literature are given. Early in the course original work on some chemical subject pertaining to agriculture must be begun. The history and results of this work must, before the awarding of the degree, be submitted in the form of a thesis containing a distinct contribution to knowledge.

ENTOMOLOGY. — I. For the degree of doctor of philosophy as a major: Some knowledge of all the divisions of this subject is essential for the professional entomologist, though a large part of his time will be devoted only to certain portions. To insure some familiarity with all these divisions, lectures, laboratory work, field training or required reading are given in each of the following topics: —

(a) *Morphology*. — Embryology; life history and transformations; histology; phylogeny and the relation of insects to other arthropods; hermaphroditism; hybrids; parthenogenesis; pedogenesis, heterogamy; chemistry of colors of insects; luminosity; deformities of insects; variation; duration of life.

(b) *Ecology*. — Dimorphism; polymorphism; warning coloration; mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migration; geological history of insects; insects as disseminators of disease; enemies of insects, vegetable and animal, including parasites.

(c) *Economic Entomology*. — General principles; insecticides; apparatus; special cases; photographs of insects and their work; methods of drawing for illustrations; field work on insects and study of life histories; legislation concerning insects.

(d) *Systematic Entomology*. — History of entomology, includ-

ing classifications and the principles of classification; laws governing nomenclature; literature, how to find and use it; indexing literature; number of insects in collections and in existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

(e) *Seminar*. — A monthly meeting of graduates, at which reports on current literature are presented and various entomological topics of importance are discussed.

(f) *Required Readings*. — The best articles on the various topics named above and on the different orders of insects, to cover from fifteen thousand to twenty thousand pages of English, French and German, the candidate to be examined at the close of his course on this with his other work.

(g) *Thesis*. — A thesis, illustrated with drawings, consisting of the results of original investigation upon one or several topics, and constituting a distinct contribution to knowledge, must be completed before the final examinations are taken.

II. For the degree of doctor of philosophy as a minor, and for the degree of master of science either as a major or minor: Such portions of the course outlined above as seem most appropriate to their other subjects are given to students taking entomology as a minor.

HORTICULTURE. — The work in horticulture necessarily varies considerably with different candidates, since its most important features are specialization, original investigation and the development of individual initiative in dealing with new questions. Each candidate must select some special field of horticultural study, and devote himself to it continuously. He will be required to attend lectures, conferences and seminars dealing with horticulture in its broader aspects, and to do advanced work in the following subjects: —

- (a) Systematic pomology.
- (b) Pomological practice.
- (c) Commercial pomology.
- (d) Systematic, practical and commercial olericulture.
- (e) Greenhouse plants and problems.
- (f) Floriculture.
- (g) Landscape gardening.
- (h) Plant breeding and general evolution.
- (i) Questions of physiology connected with propagation and pruning.

Other requirements and opportunities are (1) periodical seminars, with special lectures by prominent men from outside the college; (2) extensive and systematically planned readings; (3) frequent visits, always with definite purpose, to orchards, gardens, greenhouses, estates and libraries outside the college grounds; and (4) the preparation and publication of a thesis which shall set forth the results of the candidate's major study, and be an original and positive contribution to horticultural knowledge.

(b) *Minor Courses.*

ZOÖLOGY. — The courses in zoölogy are offered as a minor course to candidates for the degree of doctor of philosophy. They constitute an intensive course designed to give a broad outlook and to meet the needs of the specialist, and call for original investigation, laboratory dissection, technique and museum work. The subjects treated and the work done will vary according to circumstances, but may be outlined thus:—

(a) General and comparative anatomy, both gross and microscopic; ontogeny and phylogeny; life cycles, metamorphosis and metagenesis; animal associations, colonial, commensal and parasitic, and symbiotic associations of animals and plants; adaptation, adaptive radiation and parallelisms.

(b) Geologic, geographic and bathymetric distribution of animals.

(c) Systematic zoölogy, including paleozoölogy; museum and field technique.

(d) Economic zoölogy.

(e) History and development of zoölogical science.

(f) Weekly seminar and journal club meetings, in which all advanced students of zoölogy take an active part.

(g) Collateral reading; general knowledge of current zoölogical literature.

OTHER SUBJECTS. — Courses in the other subjects open to choice as minors will be outlined according to the qualification and needs of the students applying for them.

EXTENSION WORK.



EXTENSION WORK.

The extension work of the college includes the short courses and the outside activities, such as correspondence courses, lecture courses and itinerant instruction of various forms away from the college.

SHORT COURSES.

- A. Organization, Expenses and Admission.
- B. The Winter School.
- C. The Summer School.
- D. Itinerant Instruction.

A. ORGANIZATION, EXPENSES AND ADMISSION.

ORGANIZATION. — The work of the short courses in the college was organized in September, 1909, with a director in charge.

The object of the short course work is three fold: —

(1) To bring to the college for instruction for a few days or a few weeks as many people as can possibly be reached in this way.

(2) To disseminate, by various methods, agricultural information to people who cannot come to the college even for a short time.

(3) To make the college as useful as possible to all the people of the Commonwealth who are interested in agriculture and country life.

The work has been organized thus: —

1. The Winter School.

Ten weeks' general course.

Poultry course.

Farmers' week.

Beekeepers' course.

2. The Summer School.

Courses in practical agriculture and horticulture.

Courses in elementary sciences bearing on agriculture and horticulture.

Home economics.

Courses in agricultural education.

Courses in agricultural economics and rural sociology.

Courses especially for clergymen and rural social workers.

Conferences for clergymen, school superintendents, librarians and others.

Evening lectures by eminent educators.

Excursions to various points of interest in the vicinity.

3. *Itinerant Instruction.*

Correspondence courses.

Lecture courses.

Practical field demonstrations.

Travelling schools.

Educational trains (steam and trolley).

Educational exhibits at fairs.

Demonstration orchards.

Demonstration field experiments.

Services of expert agricultural authorities.

Agricultural surveys.

Advisory work with schools, State institutions and individuals.

Student extension work.

EXPENSES IN THE SHORT COURSES. — The expenses of attending either of the short courses will be about as follows: —

Tuition to citizens of the United States,	Free.
Furnished rooms with private families, per week,	\$1-\$3
Board at college dining hall, per week,	\$4
Board with private families, per week,	\$4-\$5

Students in either of the dairy courses must provide themselves with two white wash suits and a white cap for use in the practical dairy work; the cost in Amherst is about \$1.25 for suit and cap.

REQUIREMENTS FOR ADMISSION TO SHORT COURSES. — No entrance examinations are required, but students are advised to review their school work in English and arithmetic before entering. Practical experience in farm, garden, orchard or greenhouse work will be an advantage. The courses are open to both men and women. Students must be at least eighteen years of age, and must furnish satisfactory evidence of good moral character.

Application for admission should be made as early as possible. Students should report to the professor in charge on Monday, Jan. 2, 1911, in order to begin work promptly on the morning of January 3.

B. THE WINTER SCHOOL.

1. The Ten Weeks' Course.
2. The Short Course in Poultry Management.
3. Farmers' Week.
4. Beekeepers' Course.

1. THE TEN WEEKS' GENERAL COURSE.

JAN. 3—MARCH 10, 1911.

AGRICULTURE, DAIRYING, FRUIT GROWING, FLORICULTURE, MARKET GARDEN-
ING, VETERINARY SCIENCE, ETC.

a. Courses of Instruction.

b. Other Information.

a. Courses of Instruction.

1. Soil fertility. Prof. WM. D. HURD. Three exercises a week for eight weeks.
2. Market gardening. Mr. C. S. HELLER. Three exercises each week for ten weeks.
3. Fruit growing. Prof. F. C. SEARS. Five exercises each week for ten weeks.
4. Floriculture. Prof. E. A. WHITE. Five exercises each week.
5. Field crops. Prof. S. B. HASKELL. Three exercises each week for ten weeks.
6. Breeds and breeding. Prof. J. A. McLEAN. Three exercises weekly, with appointed hours for stock judging.
7. Feeding and management. Prof. J. A. McLEAN. Two exercises weekly.
8. Animal diseases and stable sanitation. Dr. J. B. PAIGE. Two exercises each week.
9. Dairying. Prof. W. P. B. LOCKWOOD and assistants. Three one-hour, 2 two-hour and 2 three-hour periods.
10. Dairy bacteriology. Prof. W. P. B. LOCKWOOD. Two exercises each week.
11. Botany. Prof. A. V. OSMUN and others. Three exercises each week.
12. Entomology. Dr. H. T. FERNALD and assistants. Three exercises each week.
13. Mechanics. Prof. W. P. B. LOCKWOOD and Mr. WALLACE. One exercise of two hours each week.
14. Farm accounts. Prof. J. A. FOORD. One exercise each week.
15. Farm buildings and machinery. Prof. J. A. FOORD and Mr. E. H. FORRISTALL. One exercise a week for ten weeks.
16. Landscape gardening. Mr. JOHN NOYES. Twenty exercises.
17. The farmer and the community. Two periods a week.
The development of the rural community, President BUTTERFIELD.
Farm labor, immigration and farmers' organizations, Dr. CANCE.
The government in rural communities, Professor EYERLY.
The educational problems of rural communities, Professor HART.
Agricultural literature, Professor HOLCOMB.

18. Forestry. Prof. F. F. MOON. Six lectures.
19. Meat, meat production and marketing on the farm. Mr. H. P. HINKLEY of Armour & Co. One demonstration each fortnight.

b. Other Information.

ASSEMBLY.—All students of the college are required to attend a weekly assembly, at which an address of general interest is usually given. Attendance at morning chapel service, four times each week, is also required.

2. POULTRY COURSE.

FEBRUARY 27 TO MARCH 10, 1911.

The purpose of this course is to give information to people interested in the poultry business.

Some of the best authorities on the subject of poultry breeding and management in this country have been secured to give the lectures and practical demonstrations.

An effort will be made to make the course a "practical" one, touching the vital problems of the poultry business.

Classes begin Monday, February 27, at 2 P.M.

Instruction will be given by specialists in poultry management, as follows:—

Prof. J. C. GRAHAM, Professor of Poultry Husbandry.

Mr. JOHN H. ROBINSON, Boston, Mass., editor of "Farm Poultry," author, and recognized authority on poultry subjects.

Prof. JAMES E. RICE, Professor of Poultry Husbandry, Cornell University, Ithaca, N. Y.

Mr. EDWIN F. GASKILL, in charge of poultry experiments at Massachusetts Experiment Station, Amherst, Mass.

Mr. D. J. LAMBERT, in charge of poultry work at Rhode Island State College, Kingston, R. I.

Mr. HENRY D. SMITH, Rockland, Mass.

Besides the poultry specialists mentioned above, the following members of the faculty of the Massachusetts Agricultural College will also give instruction in the poultry course:—

Prof. WILLIAM D. HURD, Director of Extension Work.

Dr. JAMES B. PAIGE, Professor of Veterinary Science.

Prof. FRED C. SEARS, Professor of Pomology.

Mr. C. S. HELLER, Instructor in Vegetable Gardening.

J. A. MCLEAN, Professor of Animal Husbandry.

Mr. CLARENCE A. JEWETT, Superintendent of Buildings.

Special Evening Lectures and Other Features.

Throughout the course evening lectures of a popular nature will be given.

The poultry course occurs during the last two weeks of the ten weeks' short winter course, so that those who attend the poultry course may take advantage of the lectures offered in this course as well.

Farmers' week occurs at the college the week following the close of the poultry course. Every one should plan to remain over for this.

Trips will be made to nearby commercial poultry plants to study methods, etc.

Poultry Show.

On March 8, 9 and 10, in connection with the work of the short poultry course, a poultry show will be held. This will be organized along the lines of any well-conducted show, the idea being to give the students training in preparing birds for exhibition and in showing them.

Send for entry blanks.

3. FARMERS' WEEK.

MARCH 13-17, 1911.

The work given in the 1910 farmers' week was as follows. A broader and more complete program will be carried out the present year.

Purpose and Organization of Farmers' Week.

Farmers' week is given by the Massachusetts Agricultural College for the benefit of those who cannot leave their homes or business for a sufficient length of time to take the other short courses.

Farmers' week is divided into sections, so that all who attend may find work of interest to them in progress each day.

1. General agricultural section,—including animal husbandry, dairying and poultry raising. Features of this section are "corn day," with a big corn show, and "dairy day," with exhibits of dairy machinery and dairy products.

2. General horticultural section,—including fruit growing, market gardening, floriculture and forestry. A feature of this section is "apple day."

3. Women's section, — home economics, domestic science and home making.

Eminent people are secured for the evening meetings. One day is given up to a discussion of problems of "community building."

4. BEEKEEPERS' COURSE.

MAY 24-JUNE 7, 1911.

Announcement.¹

Throughout the year the Massachusetts Agricultural College has been receiving calls for a course in beekeeping. To meet the demand, a short course, covering the lines indicated, has been arranged.

During the past year the college has come into possession of about twenty colonies of bees and some other equipment. These, together with the swarms owned by the college faculty, will give most excellent equipment.

The work as laid out is of the most practical nature, and every attempt will be made to emphasize the points which are of the most value, yet are little understood by those engaged in this industry.

The following experts in beekeeping have given the work: —

Courses and Faculty.

1. Practical phases of beekeeping. Dr. BURTON N. GATES.
2. Crops for honey bees. Dr. WM. P. BROOKS.
3. The relation of bees to the pollination of plants. Dr. GEORGE E. STONE.
4. The origin and evolution of the honey bee. Dr. HENRY T. FERNALD.
5. Bees and beekeepers' supplies. Dr. JAMES B. PAIGE.

C. THE SUMMER SCHOOL.²

JULY 3-AUG. 4, 1911.

1. Announcement, Purpose, Plan.
2. Faculty.
3. Election of Courses.
4. Conference for Rural Social Workers.

1. Announcement and General Plans.

The summer school of agriculture and country life at the Massachusetts Agricultural College opened July 11, 1910, for a term of nearly five weeks, closing August 12. This was the fourth

¹ 1910 course; 1911 course not yet ready.

² Description here given is for the 1910 school.

session of this summer school, those of the past three years having been highly successful. The experience of these three years aided in making material improvements for the session of 1910.

The work of the summer school was designed originally for school teachers, and the attendance has been largely of that class. Special attention will be given to the needs of teachers again this year. It has been found, however, that there are many persons who seek a general knowledge of theoretical and practical agriculture, and who can come to the college conveniently during the summer season. Extended courses will be offered for the benefit of such persons also.

From the courses it will be possible to make up programs of work suitable to the needs of almost every one, but especially to school teachers, principals, superintendents, school committeemen, farm owners, householders, suburban residents, clergymen, pastors, preachers, social workers, and those who have only a general interest in agriculture. Persons who are in doubt as to what courses will best suit their needs would better correspond with the director of the summer school, who will gladly advise in all such matters.

The formal instruction in the summer school was given in thirty definite courses, herein described. From these each pupil might elect courses providing not less than ten nor more than fifteen exercises a week, unless a larger or smaller amount of work be allowed by the director. These courses included a large amount of field work, observation trips, outdoor exercises and laboratory experiments.

Besides these, general field exercises will be arranged for one afternoon of each week. These will be on topics of interest to all. Class excursions will be arranged for every Wednesday afternoon, and more extended excursions for the whole school will be planned for every Saturday. These excursions will be in charge of an instructor as heretofore. In the past they have proved a very enjoyable feature of the work.

Round tables and special discussions will be arranged by various instructors as their courses require. A conference of rural social workers and educators of New England was held August 9, 10, 11 and 12. An outline of the conference will be found in another part of this bulletin.

A course of evening lectures on popular topics relating to the work of the school was a feature of the general program. Like everything else connected with the summer school this lecture course is entirely free to all students.

2. Faculty.

1. Soils and tillage. Assistant Prof. S. B. HASKELL. Five exercises weekly the first two weeks. Should be followed by Course 2.
2. Field crops. Assistant Prof. S. B. HASKELL. Five exercises each week for second two weeks. Should be preceded by Course 1.
3. Fruit growing. Prof. F. C. SEARS. Limited to 30 pupils. Five exercises weekly for four weeks.
4. Practical gardening. Mr. C. S. HELLER. Course limited to 20 pupils. Five exercises weekly, two hours each, first four weeks.
5. The study of landscape. Prof. E. A. WHITE. Five exercises weekly, first two weeks.
6. Trees and shrubs. Prof. E. A. WHITE. Five exercises weekly, second two weeks of the term. This course is especially suited to follow Course 5 and to precede Course 7.
7. Forestry. Prof. E. A. WHITE. Lectures and field exercises, five exercises weekly.
8. Domestic animals. Mr. R. L. GRIBBEN. Five hours a week, first four weeks.
9. Modern dairying. Associate Prof. W. P. B. LOCKWOOD. Five exercises weekly for four weeks.
10. School gardening. Prof. W. R. HART. Five exercises a week, first two weeks.
11. Agricultural pedagogy. Prof. W. R. HART. Five exercises weekly, beginning July 25.
12. School agriculture. Assistant Prof. F. B. JENKS. Five exercises weekly for four weeks.
13. Elementary chemistry. Associate Prof. J. CHAMBERLAIN and Assistant Prof. F. S. HOWARD. Five exercises weekly for four weeks.
14. Agricultural high school chemistry. Associate Prof. J. CHAMBERLAIN and Assistant Prof. F. S. HOWARD. Five hours a week, four weeks.
15. Plant experiments. Prof. G. E. STONE. Five exercises weekly for two weeks.
16. Plant life. Assistant Prof. A. V. OSMUN. Five lectures weekly for two weeks, beginning July 25.
17. Cryptogamic botany. Assistant Prof. A. V. OSMUN. Two three-hour exercises weekly for two weeks.
18. Bird life. Mr. C. J. MAYNARD. Five exercises weekly, first two weeks.
19. Insect life. Mr. R. MATHESON. Three class and two laboratory periods for four weeks.
20. Entomology. Mr. R. MATHESON. Three lectures and two laboratory periods for four weeks.
21. Domestic science for rural school teachers. Miss H. RINAKER. Three lectures and two cooking demonstrations weekly for four weeks.
22. Domestic science and home economics. Miss H. RINAKER. Three lectures and two demonstrations weekly for four weeks.
23. Household science. Miss H. RINAKER. Three lectures and two demonstrations of cooking weekly, beginning July 25.
24. New England agriculture. Prof. W. D. HURD. Five exercises weekly.

25. Agricultural economics. Assistant Prof. A. E. CANCE. Five lectures weekly.
26. Development of the rural community. President K. L. BUTTERFIELD. Lasts two weeks.
27. The church and the rural problem. Rev. W. L. ANDERSON. Five lectures weekly.
28. The country school and the rural community. Miss M. CARNEY. Lectures beginning August 1.
29. Forms of co-operation among farmers. Assistant Prof. E. K. EYERLY. Ten lectures.
30. Rural literature. Mr. G. M. HOLCOMB. Ten lectures.
31. The movement in agricultural education. Prof. W. R. HART. Ten lectures.

3. *Election of Courses.*

Election of courses should be made at the time of registration. Every election is subject to the approval of the director and of the instructor whose course is elected. As it will be necessary to schedule several courses at the same hour, certain combinations of courses will be made unavailable. It should be especially noticed that certain courses are offered to a limited number of pupils only, and, as a rule, pupils will be accepted in these courses in the order of application. Each pupil should choose such combinations of courses as will keep two or three subjects in hand at the same time. This will meet the requirement that each one must take at least ten and not more than fifteen exercises a week, unless permitted to take more or less by special order of the director.

Attendance will be required in the courses elected. Some sort of examination, test or permanent note-book will be required in each course. Those who complete the courses in a satisfactory manner, including practically perfect attendance, will be given certificates at the close of the term showing what work has thus been completed.

There are no rules or regulations whatever. Persons are not admitted to the summer school who are not old enough to know how to behave, and every one is expected to know and conform to the usages of good society. This absence of rules has worked admirably in the past, and it gives every one a sense of freedom based on personal responsibility, the basis of all proper government, whether in school, college or the community.

4. *Conference of Agricultural Educators and Rural Social Workers.*

The last four days of the summer school will be given over to a conference of agricultural educators, rural social workers and others who are interested in developing country life. As its name indicates, this will be a conference in every sense of the word, every one being expected to take part in the informal discussions.

It is expected that persons representing the following lines of work will be present: rural school teachers, grade teachers of agriculture, high school teachers of agriculture, college teachers of agriculture, rural clergymen, rural librarians, grange lecturers, village improvement societies and others.

The plan of the program will be as follows: each of the above sections of workers will be asked to arrange a program, covering two hours in length, for their respective sections each forenoon. An afternoon general section will be held, at which some subject, such as the education of rural communities, the social life of rural communities, the religious life of rural communities, and the organization of forces for rural betterment, will be taken up each day.

Among the prominent speakers at the 1910 conference were Dr. S. A. Knapp of Washington, D. C., Dr. Josiah Strong of New York City, and Prof. Charles Zueblin of Winchester, Mass.

The bulletin of the 1911 summer school will be ready about March 1, and can be had by applying to the director.

D. ITINERANT INSTRUCTION.

1. Correspondence Courses.
2. Lecture Courses.
3. Other Itinerant Instruction.

1. THE CORRESPONDENCE COURSES.

a. *Purpose and Description of the Work.*

The correspondence courses announced in this circular are offered by the Massachusetts Agricultural College in response to calls from all sections of the State, from people who desire agricultural information, but who, for various reasons, cannot come to the college for it. These courses are designed to meet the needs of farmers, dairymen, stock breeders, fruit growers, market gar-

deners, floriculturists and teachers, either in elementary schools, high schools, academies or normal schools.

Since agricultural science and practice have changed and are changing so rapidly, it is the purpose to give a summary of the latest information on the subjects treated, yet in such language that any who pursue the study can readily understand the work. Additional courses, covering other subjects, will be added later.

b. Method of conducting the Work.

While a large number of books have been written on various agricultural subjects, few of them are especially adapted to correspondence course work. For this reason our courses are conducted principally by especially prepared lessons. These lessons partake somewhat of the nature of the lectures given in the regular college work. Whenever possible, a text-book is used for reference and supplementary study.

The lessons are sent out one at a time by the college, and are either accompanied or followed by a list of questions. When these are satisfactorily answered or discussed, the next lesson is sent, and so on.

It is recommended that students take up the work in some logical order, *i.e.*, the courses in "soils" and "manures and fertilizers" should precede those in "field crops," "fruit growing" or "market gardening."

After these preliminary courses have been completed, two or more courses of study may be pursued at the same time, provided the student can devote sufficient time to the work to carry it on successfully.

The courses are especially recommended to granges for study, and it is to be hoped that grange lecturers, or some other interested person, will organize study classes. When this is done, a representative of the college will visit the grange from time to time to conduct the class, discuss the work and offer suggestions.

c. Description of Courses.

1. Soil and soil improvement. Prof. W. D. HURD. The cost of the course is \$1.
2. Manures and fertilizers. Prof. W. D. HURD. The cost of the course is \$1.
3. Field crops. Assistant Prof. S. B. HASKELL. The cost of the course is \$1.
4. Farm dairying. Associate Prof. W. P. B. LOCKWOOD. The cost of the course is \$1.

5. Fruit growing. Prof. F. C. SEARS and Mr. A. J. NORMAN. The cost of the course is \$1.
6. Market gardening. Mr. C. S. HELLER. The cost of the course, including the text-book, is \$2.50.
7. Animal feeding. Mr. R. L. GRIBBEN and Mr. C. J. ROBINSON. The cost of the course is \$1.
8. Floriculture. Prof. E. A. WHITE. The cost of the course is \$1.
9. Farm accounts. Prof. J. A. FOORD. The cost of the course is \$1.
10. Agriculture in the common schools. Assistant Prof. F. B. JENKS. The cost of the course, including the text-book, is \$2.10.
11. Agricultural education. Prof. W. R. HART. The cost of the course is \$1.
12. Beekeeping. Assistant Prof. B. N. GATES. The cost of the course is \$1.
13. Forestry. Associate Prof. F. F. MOON. The cost of the course is \$1.

d. Expenses of the Courses.

In order that none shall enroll but those who are interested and desire to pursue earnest study, a small fee is charged. This has been fixed at the uniform rate of \$1 for each course, payable in advance at the time of enrollment.

This fee is not charged to cover cost of preparing the course, for this, in time of the instructors, is many times what is received, but it is to defray expenses of postage and material used in the preparation of the lessons, and to insure a higher quality of work from those who enroll.

The cost of a text-book, when one is used, is in addition to this enrollment fee.

Remittances should be made by money order or check.

e. Enrollment.

Students may enroll at any time by applying to the director of extension work, either personally or by letter. Enrollment should be made on the card which is furnished by the college.

Membership in the correspondence courses entitles the student to receive the books used in the various courses, and others, at reduced prices.

f. List of Reference Books for Supplementary Reading.

For those who desire to add some of the latest books to their libraries, for teachers who wish material for their work, or for librarians who desire to place on the shelves of their libraries, the latest agricultural publications, arrangements have been made with

the Orange Judd Publishing Company, Lafayette Place, New York City, N. Y., to supply books at reduced prices.

A classified list giving prices (postpaid) will be furnished by the college to all who apply for it.

2. THE LECTURE COURSES.

The college also offers lecture courses. The lectures can be obtained by any agricultural organization, grange, farmers' club, board of trade, women's club, Young Men's Christian Association, church club or school, or by others who are interested in problems pertaining to agriculture and country life. Single lectures, or a series comprising a course, can be arranged for.

LECTURES AND SUBJECTS. — The faculty of the college are, of course, men busy with regular college duties, and can undertake only so many outside lectures as will not seriously interfere with their regular college work. For this reason it is advisable that those desiring lectures for a fixed date should make a second, and perhaps a third, choice, also, of lecturers, in order to secure some one.

A Lecture without a Lecturer.

The college is now prepared to send a stereopticon, a written lecture and a set of lantern slides to accompany the lecture to responsible persons who desire to use these before public gatherings. A rental fee of \$1 and express both ways is charged. The following lectures will be ready for the winter of 1910-11:—

Clean milk, production and handling.

Apple growing.

Types and breeds of animals.

History, uses and culture of corn.

Potato growing.

The organization and work of the Massachusetts Agricultural College.

Home and school ground decoration.

Teaching agriculture, school gardening, etc., in the public schools.

Concrete: its use on the farm.

Other subjects will be announced later.

The Practical Demonstrations.

The college is prepared to send an expert who will bring with him the necessary apparatus, whenever possible, to give practical demonstrations of different operations connected with agricultural

practice. The following are some of the demonstrations most commonly given:—

The production and handling of clean milk.

Babcock milk testing.

Scoring and judging live stock.

Spraying fruit trees.

Packing apples.

Pruning and grafting.

Scoring and judging fruit.

Corn selection and judging.

Demonstrations in beekeeping as announced by Dr. Gates in circular.

Others may be given when requested.

Terms on which Lectures and Demonstrations are given.

The idea of offering these lectures to the public is that as large a number of people of the State may receive the instruction as is possible. When no admission fee is charged, the lectures and object lessons will be given free, provided the organization or individual requesting the lecture will pay the traveling expenses of the person giving the lecture. When admission is charged, the lecturer shall receive compensation in addition to his traveling expenses.

Correspondence is invited regarding the selection of subjects for a course of lectures.

3. OTHER ITINERANT INSTRUCTION.

Besides the correspondence and lecture courses and the practical field demonstrations, the college is carrying on several kinds of itinerant instruction. Calls are constantly made on the college for help to be given at a distance from the institution; and to meet these calls a corps of field agents is being engaged. These men and women will serve as traveling instructors, giving instruction varying in length from a single lecture to traveling-school courses lasting several days.

DEMONSTRATION ORCHARDS.—The college is establishing these orchards in all sections of the State. The owner of the land furnishes four or five acres and signs a contract to carry out the instructions of the college for fifteen years. The college furnishes the trees, a spraying outfit and the necessary supervision free of charge. Renovation plots in neglected orchards are also taken by the college for improvement for a period of five years. Educational meetings are held at these orchards each season.

EDUCATIONAL TRAINS.—In the past year a train consisting of five cars, extensively equipped with demonstration apparatus, was run over the lines of the Boston & Albany Railroad. A trolley train of five cars was run over the trolley lines centering in Springfield. Fifteen lecturers and demonstrators accompanied these trains.

EDUCATIONAL EXHIBITS AT FAIRS.—The college makes exhibits at the principal fairs in the State. In connection with these exhibits an extensive lecture program is given.

TRAVELING SCHOOLS.—When so requested the college organizes itinerant schools of instruction, lasting from three to five days, in good agricultural centers. The program is somewhat similar to that given at the college “farmers’ week.” The program is given without cost, providing the cost of halls and advertising is met by the community where the school is held.

TRAVELING LIBRARIES.—To meet an increasing demand for information concerning agricultural books the college is preparing to send to libraries and schools a collection of some of the best books on agriculture and allied subjects.

Extension Work by Students.

In order to aid in a practical way in the solution of the problems in the rural community, a new line of work has been undertaken by the extension department as student extension work.

Members of the college Young Men’s Christian Association who have shown ability in community building are largely employed in this form of extension. The object of the work is two-fold: (1) to develop the country boy and acquaint him with the possibilities of the farm, indirectly reaching his parents and ultimately amalgamating the various factors of the community for the purpose of fostering a more wholesome community spirit; (2) to train the college students to cope with the rural problem in order that later they may exercise the right leadership in the community.

The work is being developed with regard to religious, educational, social and physical interests. The religious work embraces the teaching of Bible classes, leadership in singing at Christian Endeavor and other meetings, the holding of meetings in different towns by members of the college Young Men’s Christian Association, the encouragement of church socials, etc.

The educational work includes study of the social and economic problems of the town, the teaching of English to foreigners, conducting classes in agriculture, with practical work, lecturing on

agricultural subjects, beautifying home grounds, developing home flower gardens, leading nature-study tramps, organizing debates and encouraging boys to further schooling.

The social effort is to encourage and develop all activities in town tending to create a broader and more unified community interest; such activities are church entertainments, school entertainments, musicals, etc.

Physical education is given through talks about clean living and physical culture, and by development of different branches of athletics under efficient moral leadership.

The plan involves much competition, tending to bring the people of the different towns into a closer relationship.

The work thus far has been confined to those communities within easy reach of the college, but it will gradually extend over a wider area. The work is popular and promises to become one of the most important agencies in the development of the rural community.

Miscellaneous Itinerant Instruction.

A number of other kinds of work are demanded of the college through the extension work. Among these might be mentioned aid in the organization of crop and animal improvement societies, the conducting of demonstration experiments and plot tests in all sections of the State, making agricultural surveys, doing advisory work with schools, State institutions and individuals, furnishing the services of agricultural experts to those who need help, giving advice on farm management, and answering thousands of inquiries each year.

In short, the spirit of the extension work is that of service, and an effort is made through it to render the departments of the Massachusetts Agricultural College as helpful to the people of the Commonwealth as they can be. Correspondence is invited from any who desire such help as has been spoken of. Letters should be addressed to the Director of Extension Work, Massachusetts Agricultural College, Amherst, Mass.

GENERAL INFORMATION.

GENERAL INFORMATION.

A. FINANCIAL AND ADMINISTRATIVE.

STUDENT EXPENSES.

TUITION. — Tuition is free to citizens of the United States; but students who are citizens of Massachusetts should apply to the senator of the district in which they live for a free scholarship. Blank application forms may be obtained from the registrar. The tuition charged persons not citizens of the United States is \$120 a year.

DORMITORIES AND BOARD. — The college has dormitory accommodation for about 64 students. The rooms in the dormitories are occupied chiefly by the upper classmen, hence new students are obliged to room in private houses. The rooms in the college dormitories are unfurnished. They are mostly in suites of three, — one study room and two bed rooms. They are heated with steam and lighted with electricity. Students care for their rooms themselves. The rent for each person ranges from \$39 to \$66 a year. The rent for furnished rooms in private houses ranges from \$1.50 to \$3 a week for each occupant. All correspondence in regard to rooms should be addressed to the dean of the college.

Board can be had at the college dining hall. Board is furnished at cost. At present the price of board is \$4 a week. The price is determined by adding to the audited rate of the previous three months' period 5 per cent. At the end of the period, final settlement is made on the basis of actual cost.

EXPENSES.

The necessary college expenses per year are estimated as follows: —

Tuition: Citizens of Massachusetts free through State scholarships; other citizens of the United States free; foreigners, \$120 a year.

	Low.	High.
Room in college dormitories or in private houses,	\$39 00	\$110 00
Board in college dining hall, \$4 a week,	144 00	144 00
Laundry, 50 cents to 85 cents a week,	18 00	30 00
Military uniforms, first year,	13 50	13 50
Laboratory fees,	2 00	20 00
Books, stationery and other miscellaneous,	23 50	32 50
	<hr/>	<hr/>
	\$240 00	\$350 00

OTHER EXPENSES. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial demands made upon students which they should expect to meet. Chief among these are class assessments, support for the Musical Association and the Y. M. C. A., and taxes levied for maintenance of various student organizations, such as the Social Union, Athletic Association, college "Signal" (paper), etc. Such expenses vary from \$15 to \$30 a year. Additional financial responsibility is assumed by students joining a fraternity. Students rooming in college dormitories are obliged to equip their rooms with furniture. The college assumes no responsibility in regard to the safe-keeping of student furniture in dormitories, either during term time or vacation, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling the economical student will probably spend between \$250 and \$350 a year.

STUDENT AID.

SELF HELP. — A number of students find opportunities for earning money without depending on the labor fund, and many rely upon labor of some sort to earn their way through college. A few men have paid all their way through college; a great many more have paid a large part of their expenses; and many have earned a small proportion of the cost of their course. But the college recommends that no new student enter without having at least \$150 with which to pay his way until he can establish himself at work. The college does not encourage students to enter without money in the expectation of earning their way. The ordinary student will find it better either to work and accumulate money before coming to college, or to take more than four years in college, or, instead, to borrow money with which to complete his course. No student should undertake work that interferes with his studies, and students should remember that, owing to the large number of applications for labor-fund employment, no one man can receive a large amount from that source.

LABOR FUND. — An annual appropriation of \$7,500 for student labor is received from the State. So far as possible needy students will be employed in some department of the college. The Department of Agriculture and the Department of Horticulture usually afford the most work. Application for student labor should be made directly to the president. Applicants must present a certificate signed by parent or guardian and by one of the selectmen of the town in which they reside, showing that they need the

aid. Students whose department or class work is not satisfactory are not likely to be continued in student labor.

SPECIAL NOTICE TO NEEDY STUDENTS.—*In the last year or two the demand for paid labor on the part of new students has exceeded the amount of employment that the college can offer. The college cannot promise work for any students, particularly freshmen. It accordingly urges prospective students who are dependent upon their own efforts not to undertake the course before they have enough money to carry them through or nearly through the first year.*

STUDENT ACCOUNTS.

The following rules are in force concerning student accounts:—

No student will be allowed to graduate until all bills due from him to the institution are paid.

College charges, such as room rent, laboratory fees, tuition, etc., must be paid strictly in advance at the beginning of each semester. No student will be allowed to register until such payments are made.

Every student boarding at Draper Hall shall pay at the beginning of each semester at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if more than one week in arrears in his payments.

All money due for student labor shall be applied on account toward any bills that the student may owe to the institution.

LABORATORY FEES.

Botany:—	Per Semester.
Graduates,	\$4 00
Courses 2, 3,	3 00
Course 4,	2 00
Course 5,	1 00
Courses 7, 9, 11, 13,	3 00
Chemistry:—	
Courses 1, 2, 11, 13 and 14, each,	3 00
Courses 4, 5 and 6, each,	4 00
Courses 9, 10, 15, 17A, B, C or D, 18A, B, C or D,	5 00
Entomology:—	
Graduate,	3 00
Entomology 3,	3 00
Entomology 4,	3 00
Landscape gardening:—	
Landscape gardening 1, 2,	2 50
Landscape gardening 3, 4, 7, 8,	4 00
Landscape gardening 6,	1 00
Drawing 1, 2,	2 50
Zoölogy:—	
Elementary 1,	2 00
Invertebrate 3,	4 00
Vertebrate 4,	4 00

B. ACADEMIC AND DEPARTMENTAL.

DEGREES.

Those who complete the four-years course receive the degree of bachelor of science. Those who receive this degree may also, upon payment of a fee, receive the degree of bachelor of science (B.Sc.) from Boston University; but the candidate must meet the conditions imposed by the university concerning preparatory studies. The fee for graduation from the college is \$5; that for the degree of Boston University is \$10.

Graduate students who complete the assigned courses will receive the degree of master of science (M.Sc.) (fee, \$10). Credit may sometimes be allowed toward this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-years course of study and present a satisfactory thesis will be granted the degree of doctor of philosophy (fee, \$25).

Those to whom degrees are awarded must present themselves in person at commencement to receive them. Honorary degrees are not conferred.

SCHOLARSHIPS AND PRIZES.

Scholarships.

The income of gifts from different persons is distributed in scholarships to worthy students requiring aid. The funds supporting these scholarships are:—

1. The Mary Robinson fund of \$1,000, the bequest of Miss Mary Robinson of Medfield.
2. The Whiting Street fund of \$1,000, the bequest of Whiting Street of Northampton.
3. The Henry Gassett fund of \$1,000, the bequest of Henry Gassett of North Weymouth.

Prizes.

Prizes are given annually in several departments for excellence in study or for special achievement. The prizes offered for 1910 are:—

AGRICULTURE. — The Grinnell prizes (first, second and third), given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations,

oral and written, in theoretical and practical agriculture. They are \$25, \$15 and \$10.

BOTANY. — The Hills prizes (amounting to \$35), given by Henry F. Hills of Amherst, will be awarded to members of the senior class as follows: for the best herbarium, \$15; for the best collection of Massachusetts trees and shrubs, \$10; for the best collection of Massachusetts woods, \$10. No collection deemed unworthy of a prize will be considered. In 1911, a prize of \$5 is offered to that member of the sophomore class who presents the best herbarium of native flowering plants.

FORESTRY. — The J. W. D. French prize (\$25) is given by the Bay State Agricultural Society to that member of the senior class who writes the best essay on forestry.

GENERAL IMPROVEMENT. — The Western Alumni Association prize (\$25) is given to that member of the sophomore class who during his first two years in college has shown the greatest improvement in scholarship, character and example.

PUBLIC SPEAKING. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declarations in the Burnham contest, \$15 and \$10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, a gold medal and \$20 and \$15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and \$15. The preliminary contests in debate are open, under certain restrictions, to all regular students.

Winter Course Prizes for 1910.

Given by the Bowker Fertilizer Company, Boston, to the student who is most familiar with the nature and composition of fertilizers and their use, one-half ton Stockbridge fertilizer.

Military Diplomas.

Military diplomas are given to those men receiving the degree of bachelor of science who by their work in the Department of Military Science have shown themselves worthy of distinction.

These diplomas recommend those receiving them for commissions in the United States army or the militia of the several States.

EQUIPMENT.

AGRONOMY. — The work in agronomy is carried on by means of lectures, laboratory work and field work. The laboratories are in the north wing of South College. The seed laboratory is equipped with samples of the different grains and seeds of economic importance in field culture, and with apparatus for the study and testing of these seeds, including microscopes and the apparatus necessary for viability and purity tests. The soil laboratory is well equipped with apparatus for the study of the physical properties of soils, including an electric centrifuge; an electric resistance thermometer for determining soil and other temperatures; evaporimeters and drying ovens; and good balances. For the work in drainage there is available a surveyor's transit, a wye level, drainage levels, rods, steel tapes, surveyors' pins, and a set of drainage tools. The college farm may also be considered a part of the agronomy laboratory.

ANIMAL HUSBANDRY. — The most important part of the equipment for laboratory work in animal husbandry is the new judging pavilion, which will be completed by Jan. 1, 1911. This will give new opportunities for practice work in management of live stock, together with demonstrations in judging. Another very essential part of the equipment for this department is the live stock of the college farm, which includes pure bred and grade Ayrshire, Guernsey, Holstein and Jersey cattle, French coach and Percheron horses, and Berkshire swine. A set of plaster-of-paris models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine, and a collection of the different food stuffs available for the use of the New England farmer, are included in the equipment for this work.

BOTANY. — The department of botany occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. It has two lecture rooms, one seating 154 and the other seating 72 people; one seminar and herbarium room; a large laboratory for sophomore and junior work, and one for senior work; and three rooms specially fitted for graduate students. The experiment station laboratories devoted to botanical research are also in this building. A small museum contains material especially useful in the teaching and illustration of plant phenomena; and on the third floor is a collection of Massachusetts timber trees, specimens

showing peculiar formations of plant growth, and various specimens illustrative of scientific methods of treating trees.

The laboratories and lecture rooms are of modern construction, finely lighted and supplied with all necessary conveniences. The basement contains a bacteriological laboratory, a seed and soil room; and a convenient workshop provided with benches for wood and metal work, an electric motor, a power lathe, and other tools and appliances. In the senior laboratory, is a room designed especially for physiological work; this laboratory is well supplied also with apparatus for the study of simple phenomena in plant physiology, such as respiration, metabolism, transpiration, heliotropism, etc. The herbarium contains 15,000 species of flowering plants and ferns, 1,200 sheets of mosses, 1,200 sheets of lichens and liverworts, and about 12,000 sheets of fungi. The laboratory is equipped with 90 modern compound microscopes and a number of dissecting microscopes, microtomes and a large series of charts. A conservatory 28 by 70 feet is connected with the laboratory. This is designed for experiment work and for housing material often needed in the laboratory.

CHEMISTRY. — The department of chemistry has rooms adapted to chemical uses, supplied with a large assortment of apparatus and chemical materials. The lecture room on the second floor seats 70 students. Immediately adjoining it are four smaller rooms for apparatus and the preparation of materials for the lecture table. The laboratory for beginners is furnished with 40 working-tables. Each table is provided with reagents and apparatus for independent work. A well-equipped laboratory for advanced work is also provided. The weighing room has 6 balances and improved apparatus for determining densities of solids, liquids and gases. The equipment includes also a microscope, a spectroscope, a polariscope, a photometer, a barometer, numerous models, and an extensive collection of industrial charts, and there is a valuable and growing collection of specimens and samples. The latter includes rocks, minerals, soils, raw and manufactured fertilizers, foods, milk products, fibers, various other vegetable and animal products and artificial preparations of mineral and organic compounds. With this should also be mentioned a series of preparations used for illustrating the various stages of different manufactures, from raw material to finished product.

DAIRYING. — Two large, well-drained, cement-floored rooms in the South College are used for dairy work. These are equipped with a milk heater, separators, coolers and aërotors, a pasteurizer,

ripening vats, churns, butter workers, a mechanical can washer, a sterilizer, and other small apparatus necessary to a well-equipped dairy or butter factory. A third room is equipped with hand and power Babcock milk-testing machines and other apparatus used for milk and butter testing. These rooms have individual lockers for students. The new sanitary dairy and stable give an opportunity for practical laboratory work in the production and handling of certified milk.

DINING HALL. — Draper Hall, a brick colonial building, equipped with the modern conveniences of a dining hall, was opened in 1903. The dining service is under the supervision of the college.

DRAWING. — Two rooms on the second floor of Wilder Hall are occupied by the classes in drawing. They are equipped with tables and adjustable drawing stands. The necessary materials and implements are provided. The equipment includes drawing models, and plaster casts of leaves, flowers, fruits, human and architectural details, and garden ornaments, two universal drafting machines, an eidograph, centrolineads, a set of ship splines and French curves, complete water-color outfits, automatic crosshatchers and protractors.

ENTOMOLOGY. — *Entomological Laboratories.* — The equipment for work in entomology is perhaps unexcelled in this country. In the new fireproof entomological and zoölogical building, first used in the fall of 1910, are fine lecture rooms, laboratories and museums for use in the different courses. The senior laboratory will accommodate 70 students at one time; a desk, equipped with compound microscope and accessories, together with glassware, reagents, etc., and supplied with electric light and gas, is provided for each student. Dissecting microscopes, microtomes and other apparatus are available for use. The graduate laboratory is similarly equipped. It will accommodate 20 students. The large and rapidly growing collections of insects are in a room adjoining both laboratories. In the library of the building is an excellent collection of the more important books and journals treating of entomology, and many more are accessible in the college library and in the private libraries of the professors, in all making available more than 25,000 volumes, many of which cannot be found elsewhere in the United States. A card catalogue giving references to the published articles on different insects contains more than 60,000 cards, and is the largest index of its kind in the United States, and probably in the world. In the basement is a pump room where may be studied the construction of the different types of spray pump, methods of

repairing them; hose, couplings, nozzles and the other parts of spraying outfits are provided, not only for examination but for use. In another room, provided with chemical desks and apparatus, methods for the determination of the impurities and adulterations of insecticides are taught. As the insectary of the Massachusetts Agricultural Experiment Station is in the same building, the facilities it offers are also available. A greenhouse, where plants infested with injurious insects are under observation and experimental treatment, is also open to students. Photographic rooms with cameras and other photographic apparatus are provided, and the large greenhouses, gardens, orchards and grounds of the college offer further opportunities for the study of injurious insects under natural conditions.

FARM ADMINISTRATION.—The college farm of 190 acres is under the supervision of the Department of Farm Administration, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The work in this department includes the production of the common field crops, and the care and raising of the different classes of live stock mentioned under animal husbandry. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied.

FLORICULTURE.—The department of floriculture aims to give the student a thorough knowledge of all phases in greenhouse design and construction and greenhouse heating, and in the culture of florists' crops. It is intended to train men for commercial floriculture and for the management of conservatories on private estates and parks and in cemeteries. The course is outlined to combine theoretical, technical and practical work in the most comprehensive manner possible. Probably no agricultural college has a department of floriculture better equipped than this. The legislative appropriation of 1908 has made possible the erection of a durable, practical, commercial range, composed of palm, fern, orchid, violet, carnation, rose and students' houses. French Hall, with its large laboratories, class rooms and offices, furnishes excellent facilities for the purposes of instruction. Besides the new glass houses, there are older houses suitable for growing bedding plants and chrysanthemums, and frames for the growing of annual

and herbaceous perennial plants, violets and pansies. Many excellent specimens of trees and shrubs are growing on the college grounds, furnishing valuable material for the study of plant materials.

FORESTRY.—The aim of the course in forestry is to prepare men for the advanced study in forestry schools, and at the same time, by laying particular stress on local conditions, to enable them to handle the farm wood lot in the same scientific manner as the rest of the farm. The college is well situated for forestry study. There is a good forest nursery on the college grounds; also two typical farm wood lots. In the vicinity are considerable areas of typical New England forest land.

GEOLOGY.—A large, well lighted laboratory for geology, 27 by 50 feet, is in the basement of the new building for entomology, zoölogy and geology. This is equipped with cabinets, models, charts and a teaching collection of rocks. It has a seating capacity of 50 persons. Adjoining this is a smaller laboratory, 21 by 27 feet, for mineralogy, supplied with gas and cabinets for models, crystals and minerals. There is also a small laboratory for grinding thin sections and a private laboratory, 6 by 19 feet, for analysis work. The geological museum is 27 by 48 feet. It has 6 large cases for exhibition purposes.

The equipment for geology is being enlarged. At present, in addition to the general items mentioned above, it consists of a petrographic microscope, an illustrative series of thin sections, a small collection of invertebrate fossils, some casts of vertebrate fossils, a collection of the building stones of Massachusetts and a duplicate set of the Edward Hitchcock survey collection of the rocks and minerals of Massachusetts.

HEATING, LIGHTING AND POWER.—The college supplies its own light, heat and power, including electricity for the night lighting of the campus and its approaches. The machinery of the barn, the dairy and other buildings is operated by electricity generated at the power-house. The college has also a machine shop.

LANDSCAPE GARDENING.—The work in landscape gardening is developed in a strong technical four-years course; the first two years are occupied with required studies, including botany, horticulture, surveying and mathematics, and the last two years are devoted to more specialized studies in landscape gardening, arboriculture, floriculture, entomology, botany and mathematics. The environment is unusually favorable. The strictly technical work in landscape gardening is taught in light and comfortable drafting

rooms, fully furnished with instruments and accessories for thorough work. There is a well-selected library, and the equipment of surveying and drafting instruments is unusually complete and practical.

LIBRARY. — The library — stack room, reading room and office — occupies the entire lower floor of the library-chapel building. It contains nearly 34,000 volumes and a large number of pamphlets, hitherto inaccessible, but which are being put into good working order as fast as possible. Works of a scientific character predominate, but economics, literature and history are well represented and are receiving due attention. The reading room provides a variety of periodical literature, both technical and popular, encyclopedias and general reference books, and a select collection of works for general reading.

The library is now being reclassified and recatalogued, to make the splendid collection of material here gathered together readily accessible and of the greatest working value. Every effort is being made toward developing the library into a vital intellectual center of college life, of equal value to every student, teacher and teaching department. In consequence, only the most cordial relations are cherished, and the fewest and most imperative rules concerning the circulation of books and deportment are enforced.

Lectures are given to regular and short course students to enable them to make the best use of the library. Emphasis is laid upon the proper use of the card catalogue, periodical indexes, bibliographies and guides; also, in general, assigned and class-room work, and essay and debate work.

The library hours are from 7.45 A.M. to 9 P.M. every week day, and from 9 A.M. to 2 P.M. on Sundays, in term time. Shorter hours prevail during vacations.

MARKET GARDENING. — The purpose of the courses in market gardening is to acquaint the student with the theories and practice of market gardening so that he will be able to carry on the business intelligently. The equipment available for practical work consists of 10 acres of good gardening land; a large collection of horse and hand garden tools; hot-beds and cold-frames; and lettuce, cucumber and tomato houses. The students therefore have opportunity both to study and to practice the important branches of the business. Classes are taught in French Hall, a new building fitted with class rooms and a laboratory particularly equipped for floriculture and market gardening. A good library of works on vegetable gardening is available.

MATHEMATICS, PHYSICS AND CIVIL ENGINEERING. — *Surveying*. — The department has a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by doing field work. Among the larger instruments are 2 plain compasses, a railroad compass with telescope, a surveyor's transit, 3 engineer's transits with vertical arc and level, a Brandis solar transit, a solar compass, an omnimeter with verniers reading to 10 seconds, adapted to geodetic work, a Queen plane table, 2 wye levels, a dumpy level, a builder's level, a sextant, a hand level, and a large assortment of leveling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, a pantograph, a parallel rule, etc., are available. The department also has a Fairbanks cement testing outfit.

Physics. — Among the apparatus in use for instruction in general physics are a set of United States standard weights and measures, precision balances, a spherometer, vernier calipers, a projection lantern, etc.; in mechanics, a seconds clock, systems of pulleys and levers, and apparatus to illustrate the laws of falling bodies and motion on an inclined plane, and the phenomena connected with the mechanics of liquids and gases. The department is equipped with the usual apparatus for lecture illustration in heat, light and sound; in electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, including a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, a Mascart quadrant electrometer, a Siemens electro-dynamometer, and reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistances.

MILITARY SCIENCE. — This department makes use of the campus for battalion drill, and has a special building in which there is a drill room 60 by 135 feet, an armory, an office for the commandant, a field-gun and gallery practice room and a large bathroom. The national government supplies Krag-Jorgensen rifles, with complete equipments and ammunition. The State supplies instruments for the college band. Students are held responsible for all articles of public property in their possession. The college owns an excellent target range for rifle practice, lying a short distance out of the village.

PHYSICAL EDUCATION. — The gymnasium and armory has a floor space of 5,000 square feet, and is 30 feet high, well lighted and ventilated. The room used for exercise and recreation is equipped with modern developing apparatus and two hand-ball courts, and is large enough for basket ball. The apparatus can quickly be

removed to clear the floor. An out-door board track enables students to secure track practice through the winter. Steel lockers and bathrooms have been installed in North and South colleges, and the gymnasium has been fitted with a bathroom. The gymnasium is open from 9 A.M. to 10 P.M., and exercise may be taken at such hours as do not conflict with military drill or physical education classes. The regulation costume for class exercise consists of a white track suit and white, rubber-sole shoes.

POMOLOGY.—The department of pomology has 10 acres of orchard, including apple, pear, peach, plum, cherry and quince trees. Of particular interest is the large collection of these fruits on the various dwarf stocks, showing many types of training. The recent revival of interest in dwarf fruits makes these dwarf orchards of especial value to students. There is also a commercial vineyard and a smaller one; in these are shown the principal types of trellis and the leading methods of training grapes. Several acres are used in growing the various kinds of small fruits, such as strawberries, raspberries, blackberries, currants and gooseberries. There are also extensive nurseries, where all of these various types of fruits are grown, in which students may see them in all stages of development.

The department has a good equipment of orchard and nursery tools of all the principal types, the use of which enables students to learn the value of each type. For other orchard operations, such as spraying and pruning, the most approved makes of pumps, nozzles, pruning saws, knives, etc., are provided. For laboratory work in systematic pomology there is a collection of more than 100 wax models of apples and plums in natural colors, which are particularly valuable in identifying varieties of these fruits unknown to the student. The laboratory is also furnished with a large number of reference books on pomology; and fruit in a fresh condition is available in great variety, not only from the college orchards but from other parts of Massachusetts and from many other States. In 1909-10, for instance, apples for class use were received from British Columbia, Ontario, Quebec, Nova Scotia, Iowa, Wisconsin, Michigan, Connecticut, New York, Oklahoma, Kansas, Colorado, Oregon, New Jersey and Vermont, besides collections of grapes from California and citrous fruit from Florida and Texas.

PUBLIC SPEAKING.—In connection with the work in public speaking, three regular contests are held during the year. The Burnham contest in declamation is open to freshmen and sopho-

mores; the Flint contest in oratory and the annual debating contest are open (under restrictions) to all regular students. These contests furnish a very practical and necessary experience to all students interested in improving themselves in the art of public speaking. Prizes are given for excellence in the contests. Inter-college contests are arranged by the Public Speaking Council. One credit is given, except to freshmen, for a year of work in the college Debating Club.

VETERINARY SCIENCE AND BACTERIOLOGY.—The department of veterinary science and bacteriology occupies a modern laboratory and hospital stable, built in accordance with the latest principles of sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The main building contains a large working laboratory for student use, and several small private laboratories for special work. There are a lecture hall, a museum, a demonstration room, a photographing room and a work shop. The hospital stable contains a pharmacy, an operating hall, a post-mortem and dissecting room, a poultry section, a section for cats and dogs, and 6 sections, separated from each other, for horses, cattle, sheep and swine. The laboratory equipment consists of a dissectible Auzoux model of the horse and Auzoux models of the foot and the leg, showing the anatomy and the diseases of every part. The laboratories also have modern, high-power microscopes, microtomes, incubators and sterilizers, for work in bacteriology and parasitology. There are skeletons of the horse, the cow, the sheep, the dog and the pig, and a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams.

ZOÖLOGY.—The college offers increased facilities for the study of zoölogy. In the new building for entomology, zoölogy and geology are spacious laboratories for both undergraduate and graduate work. On the first floor is a large sophomore laboratory, 27 by 100 feet, with a present seating capacity of 100 persons. Adjoining this is a smaller room, 20 by 27 feet, for junior and senior courses. On the second floor is a laboratory, 20 by 32 feet, for advanced work. All laboratories are equipped with gas. The equipment consists of 80 compound microscopes and accessories, 70 dissecting microscopes, microtomes and accessories, paraffine baths, incubator, dissecting instruments, glassware and other necessary apparatus. Small aquaria and vivaria will be added.

The large amphitheater lecture hall is used jointly by the departments of entomology and zoölogy-geology. It is equipped with charts and models. The zoölogical museum is drawn upon at all times for illustrative material. The zoölogical museum is 27 by 48 feet. The main room is on the first floor of the building. Above this, on a level with the second floor, is a large gallery. On the main floor are 8 large wall cases and 5 large floor cases for exhibition purposes. The gallery has 1 large wall case and 2 floor cases, with space for 10 additional cases. The zoölogical collection consists of nearly 12,000 specimens. All the chief phyla are represented. Adjoining the museum is a preparator's room for the curator. The museum is open to the public from 1 to 5 P.M. on Saturdays, and on other week days from 3 to 5 P.M. The curator is Assistant Professor Gordon.

COLLEGE ACTIVITIES.

Religious Services.

Chapel services are held four days a week. On Wednesday, instead of chapel an afternoon assembly is held, for which an attempt is made to secure speakers who will present important current subjects. Students are required to attend chapel and assembly.

The Young Men's Christian Association of the college holds a short religious meeting in the chapel on Thursday evenings, and conducts several Bible classes. For part of the year the college and the Young Men's Christian Association unite in Sunday vespers and in Sunday morning talks in the chapel. At vespers a prominent clergyman or layman speaks.

Student Organizations.

A large number of student organizations furnish opportunity for work and leadership to students.

The Massachusetts Agricultural College Social Union has recently been established. All students become members by paying a small fee; the Union is designed to become the center of student interests. It has equipped in North College a trophy room and a large lounging room for music, reading and study. In the basement of this building there is also a game room for pool and billiards. The Union gives, in the fall and winter months, a series of entertainments, free to the students and faculty.

The Young Men's Christian Association is active both socially and religiously.

The College Senate is composed of representatives of the senior and junior classes. It serves as a general director of undergraduate conduct, and represents before the faculty the interests of the student body.

The musical organizations include an orchestra, a glee club, and a quartette. These furnish music for college meetings, and occasionally give concerts. A military band is maintained as part of the cadet corps.

The Athletic Association represents in the college the interests of the football, baseball, track, hockey and tennis teams.

Among the other clubs are the Rifle Club, the Mettewampe Club, organized for walking and other outdoor recreation, and a debating club. Provision is made for credit for a specified amount of work done under supervision in the Debating Club, and intercollege debates are held. The Public Speaking Council was organized in March, 1910.

The college publications are the "Signal," published weekly by the student body, and the "Index," published annually by the junior class.

Clubs, Conferences and Seminars.

The All M. A. C. Chemists is an organization of all persons interested in chemistry who have been connected with the college in the past or are now connected with it. This club, by meetings, lectures, excursions, etc., promotes instruction in practical agricultural chemistry.

The Stockbridge Club is an organization of students specially interested in practical agriculture, horticulture and floriculture. Regular meetings are addressed by outside speakers, and members present papers and engage in discussions.

The Language Conference, meeting about once a month, is composed of the instructors in the departments of English and Modern Languages and the students who are enrolled in elective courses in these departments.

A seminar for juniors and seniors is conducted by the division of agriculture. The division of horticulture likewise conducts conferences or seminars.

An entomological club and a zoölogical club are also maintained by those specially interested in these departments of college work.

PRIZES AWARDED FOR THE YEAR 1910.

GRINNELL PRIZES. — First prize, \$25, Frank Tuttle Haynes; second prize, \$15, Roger Sherman Eddy; third prize, \$10, Francis Stone Beeman.

BOTANICAL PRIZES. — For the best herbarium, \$15, Sumner Cushing Brooks. For the best collection of Massachusetts trees and shrubs, \$10, Sumner Cushing Brooks. For the best collection of Massachusetts woods, \$10, Sumner Cushing Brooks.

FORESTRY PRIZE. — For the best essay on arboriculture, \$25, Edgar Morton Brown.

GENERAL IMPROVEMENT PRIZE. — Given to that member of the sophomore class who, during his first two years in college, has shown the greatest improvement in scholarship, character and example; \$25, Herbert James Stack.

PRIZES IN PUBLIC SPEAKING. — In debating: Irving Craig Gilgore, 1911, \$15, and gold medal; Harold Francis Willard, 1911, \$15, and gold medal; Benjamin Gilbert Southwick, 1912, \$15, and gold medal. In oratory: Theodore Joseph Moreau, 1912, \$20, and gold medal; Louis Brandt, 1910, \$15. In declamation: Horace Mitchell Baker, 1913, \$15; Frederick David Griggs, 1913, \$10.

MILITARY HONORS. — The following officers were reported to the Adjutant-General of the United States and to the Adjutant-General of Massachusetts for their high merit in military work: Maj. Roger Sherman Eddy, Capt. Henry Alvan Brooks, Capt. Frank Tuttle Haynes, Capt. Horace Wells French, Capt. Edward Harrison Turner, First Lieut. Lawrence S. Dickinson.

DEGREES CONFERRED AND
ROLL OF STUDENTS.



DEGREES CONFERRED—1910.

MASTER OF SCIENCE.

Chapman, George Henry, Amherst, Massachusetts Agricultural College, B.Sc.,
1907.

BACHELOR OF SCIENCE (B.Sc.).

Allen, Rodolphus Harold,	Fall River.
Annis, Ross Evered,	Natick.
Armstrong, Robert Pierson,	Rutherford, N. J.
Bailey, Dexter Edward, ¹	Tewksbury.
Bailey, Justus Conant,	Wareham.
Beeman, Francis Stone,	West Brookfield.
Blaney, Jonathan Phillips,	Swampscott.
Brandt, Louis,	Everett.
Brooks, Henry Alban, ^{1, 2}	Cleveland, O.
Brooks, Sumner Cushing, ²	Amherst.
Brown, Louis Carmel, ¹	Bridgewater.
Burke, Edward Joseph, ²	Holyoke.
Clarke, Walter Rowe, ¹	Milton-on-Hudson, N. Y.
Cloues, William Arthur,	Warner, N. H.
Cowles, Henry Trask, ²	Worcester.
Damon, Edward Farnham, ²	Concord Junction.
Dickinson, Lawrence Sumner, ^{1, 2}	Amherst.
Eddy, Roger Sherman, ¹	Dorchester.
Everson, John Nelson,	Hanover.
Fisk, Raymond John,	Danvers.
Folsom, Josiah Chase, ¹	Billerica.
Francis, Henry Russell,	Dennisport.
French, Horace Wells, ¹	Pawtucket, R. I.
Haynes, Frank Tuttle, ¹	Sturbridge.
Hayward, Warren Willis,	Millbury.
Hazen, Myron Smith,	Springfield.
Holland, Arthur Witt,	Shrewsbury.
Hosmer, Charles Irwin,	Turners Falls.
Johnson, William Clarence, ¹	South Framingham.
Leonard, William Edward, ²	Belmont.
McLaine, Leonard Septimus, ^{1, 2}	New York, N. Y.
Mendum, Samuel Weis, ²	Roxbury.
Nickless, Fred Parker,	Billerica.
Oertel, Charles Andrew,	South Hadley Falls.
Partridge, Frank Herbert,	Cambridge.
Paulsen, George William, ¹	New York, N. Y.

¹ Military diploma.

² Boston University diploma.

Schermerhorn, Lyman Gibbs, ¹	.	.	.	.	Kingston, R. I.
Thomas, Frank Lincoln, ¹	.	.	.	.	Athol.
Turner, Edward Harrison, ¹	.	.	.	.	Reading.
Urban, Otto Velorous Taft, ¹	.	.	.	.	Upton.
Vinton, George Newton,	.	.	.	.	Sturbridge.
Waldron, Ralph Augustus,	.	.	.	.	Hyde Park.
Wallace, William Newton, ²	.	.	.	.	Amherst.

Total, 43.

¹ Military diploma.

² Boston University diploma.

ROLL OF STUDENTS.

GRADUATE STUDENTS. — CANDIDATES FOR A DEGREE.

Anderson, David Wadsworth,	Manchester, N. H.,	-	-
B.Sc., New Hampshire State College,	1910.		
Bartlett, Oscar Christopher,	Westhampton,	-	-
B.Sc., Massachusetts Agricultural College,	1909.		
Bourne, Arthur Israel,	Kensington, N. H.,	-	-
A.B., Dartmouth College,	1907.		
Holland, Edward Bertram,	Amherst,		28 North Prospect Street.
M.Sc., Massachusetts Agricultural College,	1892.		
McLaine, Leonard Septimus,	New York, N. Y.,	-	-
B.Sc., Massachusetts Agricultural College,	1910.		
Merrill, Joseph Henry,	Danvers,	-	-
B.Sc., Dartmouth College,	1905.		
Regan, William Swift,	Northampton,	-	-
B.Sc., Massachusetts Agricultural College,	1908.		
Shaw, Jacob Kingsley,	Amherst,		1 Allen Street.
B.Sc., University of Vermont, 1899; M.S., Massachusetts Agricultural College,	1908.		
Smith, Philip Henry,	Amherst,		102 Main Street.
B.Sc., Massachusetts Agricultural College,	1897.		
Smulyan, Marcus Thomas,	Amherst,	-	-
B.Sc., Massachusetts Agricultural College,	1909.		
Summers, John Nicholas,	Campello,	-	-
B.Sc., Massachusetts Agricultural College,	1907.		
Thomas, Frank Lincoln,	Athol,	-	-
B.Sc., Massachusetts Agricultural College,	1910.		
Waters, Theodore Charles,	Rocky Hill, Conn.,	-	-
B.Sc., Massachusetts Agricultural College,	1909.		

GRADUATE STUDENTS. — NOT CANDIDATES FOR A DEGREE.

Greenfield, Melvin Leroy,	Durhamville, N. Y.,	1 Allen Street.
A.B., Colgate,	1908.	
Lawton, Ruth White,	Longmeadow,	Longmeadow.
A.B., Vassar College,	1910.	

Total, 15.

SENIOR CLASS.

Adams, James Fowler, ¹	Melrose,	11 South College.
Allen, Park West,	Westfield,	18 South College.
Baker, Herbert Jonathan,	Selbyville, Del.,	15 North College.
Barrows, Raymond Corbin,	Stafford Springs, Conn.,	5 South College.
Bentley, Arnold Gordon, ¹	Hyde Park,	4 South College.
Blaney, Herbert Wardwell,	Swampscott,	C. S. C. House.
Brown, Edgar Morton,	Merrick,	Theta Phi House.
Burnham, Arthur James, ¹	Holyoke,	75 Pleasant Street.
Bursley, Allyn Parker,	West Barnstable,	Theta Phi House.
Conant, Arthur Theodore,	Sunderland,	7 North College.
Damon, Charles Murray, ¹	Haydenville,	20 South College.
Davis, Egbert Norton,	South Framingham,	7 North College.
Davis, Irving Wilder,	Lowell,	Insectary, M. A. C.
Drury, Harold Blake,	Athol,	6 North College.

¹ Work incomplete.

Dudley, John Edward, Jr., ¹	Newton Center,	11 North College.
Gilgore, Irving Craig,	Central Square, N. Y.,	4 South College.
Hill, Nathaniel Herbert, ¹	Princeton, N. J.,	17 South College.
Howe, Harold Hosmer, ¹	Springfield,	Wilder Hall, M. A. C.
Jenks, Albert Roscoe, ¹	Three Rivers,	Plant House, M. A. C.
Johnson, Leonard Matthews, ¹	Easthampton,	6 South College.
Labouteley, Gaston E.,	Lynn,	Plant House, M. A. C.
Larrabee, Edward Arthur,	Winthrop,	Clark Hall, M. A. C.
Lull, Robert Delano,	Windsor, Vt.,	9 Fearing Street.
McGraw, Frank Dobson, ¹	Fall River,	C. S. C. House.
McLaughlin, Frederick Adams,	Lee,	15 North College.
Morse, Henry Bowditch, ¹	Salem,	75 Pleasant Street.
Nagai, Isaburo,	Tokyo, Japan,	10 North College.
Nickerson, George Payne,	Amherst,	17 South College.
Nielsen, Gustaf Arnold, ¹	West Newton,	C. S. C. House.
Ostrolenk, Bernhard,	Gloversville, N. Y.,	12 North College.
Parsons, Samuel Reynolds,	North Amherst,	North Amherst.
Patch, Roland Harrison,	Wenham,	4 North College.
Pauly, Herman Alfred,	Plainfield, Vt.,	14 North College.
Pickard, Percy William,	Hopedale,	5 South College.
Piper, Ralph Waldo,	South Acton,	12 South College.
Prouty, Frank Alvin, ¹	Worcester,	9 South College.
Prouty, Philip Herman,	Shrewsbury,	West Experiment Station.
Racieot, Philias Armand,	Lowell,	16 South College.
Robinson, Ralph Cushing,	Boston,	9 South College.
Sharpe, Arthur Harris, ¹	Saxonville,	2 South College.
Smith, Clarence Albert,	Northampton,	12 South College.
Smith, Raymond Goodale, ¹	Lynn,	3 Fearing Street.
Stevenson, Lomas Oswald,	Hackensack, N. J.,	87 Pleasant Street.
Warren, Edward Irving, ¹	Leicester,	16 South College.
Whitney, Raymond Lee,	Brockton,	6 Maple Avenue.
Willard, Harold F.,	Leominster,	18 South College.
Winn, Ervin Lawrence,	Holden,	87 Pleasant Street.

Total, 47.

JUNIOR CLASS.

Ackerman, Arthur John, ¹	Worcester,	7 South College.
Beals, Carlos Loring,	Sunderland,	Chemical Laboratory.
Beers, Rowland Trowbridge, ¹	Billerica,	20 South College.
Bent, William Richard,	Marlborough,	2 North College.
Bodfish, Edward Hill,	West Barnstable,	6 Phillips Street.
Boland, Eric Nichols,	South Boston,	13 Fearing Street.
Brett, Alden Chase, ¹	North Abington,	2 South College.
Brown, Merle Raymond,	Greenwich Village,	92 Main Street.
Burr, Frederick Huntington, ¹	Worthington,	16 North College.
Caldwell, Lawrence Sanborn, ¹	Lynnfield Center,	5 North College.
Carpenter, Jesse, Jr., ¹	Attleborough,	9 North College.
Castle, Fred Arlo,	Kansas City, Mo.,	13 South College.
Clapp, Raymond Kingsley,	Westhampton,	16 North College.
Curran, Daniel Joseph,	Marlborough,	Lover's Lane.
Dee, John Francis,	Worcester,	Lincoln Avenue, at Mrs. Spear's.
Deming, Winfred Griswold,	Wethersfield, Conn.,	15 Fearing Street.
Dodge, Albert Wesley,	Wenham,	13 North College.
Eisenhaure, John Louis, ¹	North Reading,	-
Ells, Gordon Waterman, ¹	Haverhill,	Walker's House.
Fagerstrom, Leon Emanuel, ¹	Worcester,	1 North College.
Fisherdiok, Warren Francis,	Amherst,	26 South Pleasant Street.
Fitts, Frank Orus, ¹	North Amherst,	R. J. Goldberg's.
Fitzgerald, John Joseph,	Holyoke,	33 Elm Street, Holyoke.
Fowler, George Scott, ¹	Wayland,	44 Pleasant Street.
Frost, John Newton, ¹	Natick,	77 Pleasant Street.

¹ Work incomplete.

Gallagher, James Andrew, . . .	North Wilmington, . . .	25 Lincoln Avenue.
Gaskill, Lewis Warren, . . .	Hopedale, . . .	Experiment Station.
Gelinas, Louis Edmond, ¹ . . .	North Adams, . . .	14 North College.
Gibbs, Robert Morey, . . .	Chester, . . .	Walker Hall.
Gibson, Lester Earl, ¹ . . .	Melrose, . . .	6 Maple Avenue.
Gray, Frank Leonard, . . .	East Boston, . . .	21 Fearing Street.
Hallowell, Royal Norton, . . .	Jamaica Plain, . . .	Mathematical Building.
Hamblin, Stephen Francis, . . .	Marston Mills, . . .	44 Triangle Street.
Hammond, Arthur Augustus, ¹ . . .	Wallingford, Conn., . . .	Phi Gamma Delta House.
Harlow, Joseph Alvin, . . .	Turners Falls, . . .	5 North College.
Heald, Jay Morrill, . . .	Watertown, . . .	2 North College.
Hemenway, Thomas, . . .	Winchester, . . .	West Experiment Station.
Hickey, Francis Benedict, . . .	Brockton, . . .	C. S. C. House.
Hills, Frank Burrows, . . .	Bernardston, . . .	8 South College.
Holland, Henry Lucius, . . .	Amherst, . . .	28 North Prospect Street.
Hutchings, Herbert Colby, ¹ . . .	South Amherst, . . .	13 North College.
Kingsbury, Arthur French, . . .	Medfield, . . .	Chemical Laboratory.
Lamson, Robert Ward, . . .	Amherst, . . .	51 Pleasant Street.
Lin, Dau Yang, . . .	Shanghai, China, . . .	21 Fearing Street.
Lodge, Charles Albert, ¹ . . .	Manchester, . . .	85 Pleasant Street.
Lloyd, Edward Russell, ¹ . . .	Boston, . . .	25 Lincoln Avenue.
Madison, Francis Spink, . . .	East Greenwich, R. I., . . .	Veterinary Laboratory.
Martin, James Francis, . . .	Amherst, . . .	19 South East Street.
McGarr, Thomas Anthony, ¹ . . .	Worcester, . . .	3 North College.
Merkle, George Edward, ¹ . . .	Amherst, . . .	East Street.
Merrill, Fred Sawyer, . . .	Danvers, . . .	85 Pleasant Street.
Moreau, Theodore Joseph, . . .	Turners Falls, . . .	10 South College.
Müller, Alfred Frederick, ¹ . . .	Jamaica Plain, . . .	3 North College.
Noyes, Harry Alfred, . . .	Marlborough, . . .	Chemical Laboratory.
O'Flynn, George Bernhard, ¹ . . .	Worcester, . . .	75 Pleasant Street.
Parker, Ralph Robinson, . . .	Malden, . . .	C. S. C. House.
Pearson, Charles Cornish, . . .	Arlington, . . .	14 South College.
Peckham, Curtis, . . .	Clifford, . . .	C. S. C. House.
Philbrick, William Edwin, . . .	Taunton, . . .	14 South College.
Pierpont, John Edward, . . .	Williamsburg, . . .	C. S. C. House.
Pratt, Marshall Cotting, . . .	Holderness, N. H., . . .	Kappa Sigma House.
Puffer, Stephen Perry, . . .	North Amherst, . . .	North Amherst.
Raymond, Arthur Nathaniel, . . .	Leominster, . . .	79 Pleasant Street.
Reed, Robert Edward, ¹ . . .	Abington, . . .	Theta Phi House.
Robinson, Earle Johnson, ¹ . . .	Hingham, . . .	8 South College.
Rockwood, Lawrence Peck, . . .	Waterbury, Conn., . . .	116 Pleasant Street.
Sanctuary, William Crocker, . . .	Amherst, . . .	Mill Valley.
Sellew, Lewis Raymond, . . .	Natick, . . .	Brooks Farm.
Shaw, Ezra Ingram, . . .	Amherst, . . .	8 Spaulding Street.
Southwick, Benjamin Gilbert, . . .	Buckland, . . .	8 North College.
Stack, Herbert James, . . .	Conway, . . .	Plant House.
Terry, Leon, . . .	Springfield, . . .	8 Walnut Street.
Torrey, Ray Ethan, . . .	North Leverett, . . .	East Pleasant Street.
Tower, Daniel Gordon, . . .	Roxbury, . . .	15 South College.
Tupper, George Wilbur, ¹ . . .	Jamaica Plain, . . .	85 Pleasant Street.
Turner, Howard Archibald, . . .	Dorchester, . . .	Plant House.
Wales, Robert Webster, . . .	North Abington, . . .	Kappa Sigma House.
Walker, Herman Chester, ¹ . . .	Marlborough, . . .	Walker Hall.
Warner, Roger Andrew, ¹ . . .	Sunderland, . . .	4 North College.
Weaver, William Jack, . . .	Alandar, . . .	10 Allen Street.
Whitney, Charles Everett, . . .	Wakefield, . . .	Walker's Hall.
Wilbur, Emory Sherman, . . .	East Wareham, . . .	Plant House.
Wilde, Earle Irving, . . .	Taunton, . . .	9 North College.
Williams, Edward Roger, ¹ . . .	Concord, . . .	1 North College.
Williams, Silas, . . .	Fall River, . . .	Theta Phi House.
Wood, Howard Holmes, ¹ . . .	Shelburne Falls, . . .	15 South College.
Young, Edwin Burnham, ¹ . . .	Dorchester, . . .	8 North College.

Total, 87.

¹ Work incomplete.

SOPHOMORE CLASS.

Adams, Winford Frederic, ¹	East Leverett,	2 Allen Street.
Allen, Harry Willis,	Amherst,	Amherst.
Anderson, Oscar Gustaf,	East Pepperell,	Entomological Laboratory.
Angier, Harris William,	Westborough,	88 Pleasant Street.
Baird, Harry Albert, ¹	Somerville,	Bungalow, Lover's Lane.
Baker, Dean Foster,	New Bedford,	Walker Hall.
Baker, Horace Mitchell,	Selbyville, Del.,	Kappa Sigma House.
Barber, George Ware,	Franklin,	120 Pleasant Street.
Barstow, Harold Dunbar, ¹	Hadley,	84 Pleasant Street.
Birdsall, Webster Jennings, ¹	Otego, N. Y.,	6 Maple Avenue.
Blake, Ralph Cedric, ¹	Wollaston,	President's House, M. A. C.
Borden, Ralph James,	Fall River,	Phillips Street.
Bradley, John Watling, ¹	Groton,	Theta Phi House.
Brewer, Charlesworth Herbert, ¹	Mt. Vernon, N. Y.,	85 Pleasant Street.
Brown, Herbert Augustine,	Saxonville,	79 Pleasant Street.
Bullard, Alvan Henry,	South Framingham,	5 McCellan Street.
Burby, Lawrence Walter, ¹	Chicopee Falls,	Theta Phi House.
Bursley, Harold Barrows,	Peabody,	Theta Phi House.
Caldwell, David Story,	South Byfield,	Brooks Farm.
Carver, John Stuart,	Roslindale,	85 Pleasant Street.
Chun, Woon Young, ¹	Shanghai, China,	90 Pleasant Street.
Clark, Norman Russell,	Worcester,	College Store.
Clegg, Frank Jackson,	Fall River,	C. S. C. House.
Cobb, Joseph Boyd, ¹	Chicopee Falls,	84 Pleasant Street.
Cole, Arlin Tower, ¹	West Chesterfield,	44 Triangle Street.
Cole, Flora Atwood,	Watertown,	Draper Hall.
Coleman, Isaac, ¹	Amherst,	12 North College.
Cooper, Everett Hanson,	Greenwood,	Walker Hall.
Cory, Harold,	Rutherford, N. J.,	82 Pleasant Street.
Covill, Joseph Warren, ¹	West Roxbury,	7 South College.
Cristman, Clyde Edward,	Dalton,	44 Triangle Street.
Curtis, Harold William,	Belchertown,	Belchertown.
Dayton, James Wilson,	South Norwalk, Conn.,	25 College Street.
Dooley, Thomas Patrick,	South Boston,	35 East Pleasant Street.
Drury, Lewis Floyd,	Rutland,	120 Pleasant Street.
Edminster, Albert Franklin,	Brooklyn, N. Y.,	Mount Pleasant.
Ellis, Benjamin Ward,	Plymouth,	Clark Hall.
Fay, Robert Sedgwick,	Monson,	84 Pleasant Street.
Forbush, Wallace Clifford,	Rutland,	R. J. Goldberg's.
French, James Dudley,	Hyde Park,	116 Pleasant Street.
Gaskill, Ralph Hicks,	Amherst,	15 Hallock Street.
Godvin, Thomas Joseph, ¹	Jamaica Plain,	75 Pleasant Street.
Goodnough, Henry Edward, ¹	Wilbraham,	Kappa Sigma House.
Gore, Harold Martin,	Wollaston,	11 South College.
Greenleaf, George Freeman, ¹	Brockton,	21 Fearing Street.
Griffin, William Gerald,	South Hadley Falls,	35 East Pleasant Street.
Griggs, Frederick David,	Chicopee Falls,	84 Pleasant Street.
Guild, Louis Franklin, ¹	Swanton, Vt.,	Thompson House.
Harris, Burton Adams, ¹	Wethersfield, Conn.,	66 Pleasant Street.
Hasey, Willard Harrison,	Brockton,	C. S. C. House.
Hatch, Herbert Tilden,	Norwell,	East Experiment Station.
Hayden, William Vassall, ¹	Beverly,	Walker Hall.
Headle, Herbert Wallace,	Bolton,	Mrs. L. H. Taylor's.
Headle, Marshall,	Bolton,	Mr. Lewis Howard's.
Holden, James Loomis,	Palmer,	5 McCellan Street.
Howe, Glover Elbridge,	Marlborough,	11 North College.
Howe, Ralph Wesley,	East Dover, Vt.,	116 Pleasant Street.
Hubert, Benjamin Franklin,	White Plains, Ga.,	48 Mount Pleasant Street.
Huntington, Samuel Percy,	Lynn,	Kappa Sigma House.

¹ Work incomplete.

Hutchison, Robert B., ¹	Somerville,	11 Phillips Street.
Hyland, Harold Wilson, ¹	Weymouth,	Kappa Sigma House.
Jenney, Herbert Hedge, .	South Boston,	116 Pleasant Street.
Jones, Harold Frederick, .	Campello,	120 Pleasant Street.
Jordan, Simon Miller, . .	Rutherford, N. J., . .	Walker's House.
Kelley, Albert Joseph, . .	Roxbury,	75 Pleasant Street.
Kelley, Bernard Jenkins, .	Harwich,	116 Pleasant Street.
Kenney, Frederick Alfred, .	Charlestown,	77 Pleasant Street.
Lake, James Edward, . . .	Fall River,	5 McCellan Street.
Lane, William Francis, . .	Leominster,	Phillips Street.
Larsen, Nils Paul,	Bridgeport, Conn., . .	Clark Hall.
Lesure, John Warren Thos.,	Lunenburg,	94 Pleasant Street.
Little, Willard Stone, . .	Newburyport,	120 Pleasant Street.
Lowry, Quincy Shaw, ¹ . .	Canton,	Kappa Sigma House.
Lyon, Harold,	Somerville,	116 Pleasant Street.
Macone, Joseph Augustine, ¹	Concord,	116 Pleasant Street.
Mallett, George Alfred, . .	Bridgeport, Conn., . .	Walker Hall.
Marsh, Frank Eugene, ¹ . .	Jefferson,	Experiment Station Barn.
Matz, Julius, ¹	Boston,	112 Pleasant Street.
Mayer, John Lawrence, . .	South Boston,	35 East Pleasant Street.
McDougall, Allister Francis,	Westford,	Brooks Farm.
Moir, William Stuart, . .	Boston,	35 North Prospect Street.
Murray, Joseph Wilbur, . .	Holyoke,	75 Pleasant Street.
Neal, Ralph Thomas, . . .	Mattapan,	120 Pleasant Street.
Nichols, Norman Joseph, . .	Everett,	Mrs. L. H. Taylor's.
O'Brien, James Leo, . . .	Wayland,	The Bungalow, Lover's Lane.
Packard, Clyde Monroe, . .	Springfield,	96 Pleasant Street.
Parsons, Robert,	Lynn,	44 Triangle Street.
Pease, Lester Newton, . . .	Meriden, Conn., . . .	84 Pleasant Street.
Pellett, John Doubleday, ¹	Worcester,	20 North College.
Pillsbury, Joseph James, ¹	West Bridgewater, . .	8 South Prospect Street.
Post, George Atwell, ¹ . .	Richmond Hill, N. Y.,	Theta Phi House.
Prouty, Roy Henry, ¹ . . .	Worcester,	Walsh's House.
Putnam, Earl Francis, ¹ . .	Easthampton,	5 McCellan Street.
Roberts, Clarence Dwight, ¹	New Haven, Conn., . .	10 Allen Street.
Roehrs, Herman Theodore, .	New York, N. Y., . .	83 Pleasant Street.
Rosebrooks, Walter Edwin, .	Millbury,	Care of Mrs. Tripp, East Pleasant Street.
Samson, Stuart Dodge, . . .	Grand Isle, Vt., . . .	Kappa Sigma House.
Selden, John Lincoln, ¹ . .	Northampton,	3 McCellan Street.
Serex, Paul, Jr.,	Jamaica Plain,	75 Pleasant Street.
Sheehan, Dennis Anthony, .	South Lincoln,	Walker Hall.
Shute, Carl August, ¹ . . .	Hampden,	120 Pleasant Street.
Streeter, Charles Marsh, . .	Brimfield,	R. J. Goldberg's.
Thayer, Clark Leonard, . .	Enfield,	77 Pleasant Street.
Tucker, Waldo Guy,	Lynn,	19 Pleasant Street.
Tupper, Arthur Somerville, .	Roxbury,	85 Pleasant Street.
Van Zwaluwenburg, Reyer Herman,	Rutherford, N. J., . .	East Experiment Station.
Walker, Charles Dexter, ¹ . .	Greenwich Village, . .	120 Pleasant Street.
Wells, Nathan Holmes, ¹ . .	Kennebunk, Me., . . .	Care of Mrs. E. W. Smith, North Prospect Street.
Whitney, Francis Wellington,	Needham,	15 Hallock Street.
Zabriskie, George, 2d, . . .	Rutherford, N. J., . .	Pleasant Street.

Total, 110.

FRESHMAN CLASS.

Abbott, Leslie Elmer, . . .	Sandwich,	Brooks Farm.
Allbee, Gerard Osias, . . .	Medway,	Mount Pleasant, care of Ora Samuel Gray.
Allen, Carl Murdough, . . .	Holyoke,	3 Fearing Street.
Anapolsky, Morris,	Boston,	8 Walnut Street.

¹ Work incomplete.

Anderson, Leslie Oscar,	Concord,	55 Pleasant Street.
Baker, Melville,	West Medford,	Campion's, Pleasant Street.
Besser, Sidney Stokes,	Gilbertville,	Brooks Farm.
Bickford, Horace Mann,	East Braintree,	116 Pleasant Street.
Bittinger, Fritz John,	Plymouth,	120 Pleasant Street.
Blackhall, Allan John,	Brookline,	17 Fearing Street.
Bokelund, Chester,	Worcester,	31 East Pleasant Street.
Bragg, Ralph Stanley,	Milford,	Mount Pleasant.
Brewer, Harold William,	Mount Vernon, N. Y.,	Care of Mrs. Dyer, Phillips Street.
Brooks, Arthur Winslow,	New Bedford,	Brooks Farm.
Brown, Harry Dunlap,	Lowell,	82 Pleasant Street.
Caldwell, Delmont Leo,	Dorchester,	6 Nutting Avenue.
Calvert, Melville Bradford,	New London, Conn.,	58 Pleasant Street.
Chapon, Robert Henri,	Bangor, Me.,	83 Pleasant Street.
Christie, Edward Wheeler,	North Adams,	29 Lincoln Avenue.
Clark, Ernest Samuel, Jr.,	Tolland,	96 Pleasant Street.
Clay, Harold Johnson,	Cambridge,	21 Fearing Street.
Coe, Alfred Lynn,	New York, N. Y.,	Mrs. L. H. Taylor's, North Amherst.
Cole, Herbert Elmer,	Three Rivers,	120 Pleasant Street.
Coleman, David Augustus,	South Framingham,	29 McCellan Street.
Culley, Frank Hamilton,	Marshalltown, Ia.,	30 North Prospect Street.
Damon, Samuel Reed,	Kingston, R. I.,	77 Pleasant Street.
Davies, Lloyd Garrison,	Peabody,	3 McCellan Street.
Davis, Ralph Edward,	Southbury, Conn.,	77 Pleasant Street.
Davis, William Ashmun,	Sunderland,	Care of E. H. Forristall.
Dearing, Newton Howard,	Brookline,	11 Cottage Street.
Demond, Robert Norton,	Stafford Springs, Conn.,	Care of E. H. Forristall.
Dexter, Evans King,	Mattapoisett,	31 East Pleasant Street.
Dunbar, Erving Walker,	North Weymouth,	5 Sunset Avenue.
Dunne, Robert Ernest,	New York, N. Y.,	17 Kellogg Avenue.
Earle, Henry Weston,	Roxbury,	108 Pleasant Street.
Edgerton, Almon Morley,	West Springfield,	Nutting Avenue.
Edmonds, Sidney Wilfred,	Roslindale,	60 Pleasant Street.
Edwards, Edward Clinton,	Salem,	15 Cottage Street.
Elder, William Arthur,	Irvington, N. Y.,	56 Pleasant Street.
Eldridge, Harold Lockwood,	Wareham,	M. A. C. Grounds.
Farrar, Stuart Kittredge,	Springfield,	35 East Pleasant Street.
Foster, Stuart Brooks,	West Somerville,	16 Pleasant Street.
Freeborn, Stanley Barron,	Marlborough,	116 Pleasant Street.
Freedman, Samuel Leavitt,	Roxbury,	13 East Pleasant Street.
Frost, Robert Theodore,	New York, N. Y.,	Care of Mrs. Dyer, Phillips Street.
Frye, Carl Raymond,	South Hadley Falls,	East Pleasant Street.
Gare, Edward John,	Northampton,	101 Pleasant Street.
Gibson, David Wyman,	Groton,	Care of Mrs. L. H. Taylor's, North Amherst.
Graves, Benjamin Robert,	Northampton,	58 Pleasant Street.
Grebin, Mark Anthony,	North Hadley,	North Hadley.
Hadfield, Harold Frederick,	North Adams,	29 Lincoln Avenue.
Handy, Ralph Ellis,	Cataumet,	Brooks Farm.
Harriman, Vincent Spaulding,	Brockton,	19 Hallock Street.
Harris, Rodney Wells,	Wethersfield, Conn.,	66 Pleasant Street.
Haskell, Willard Anderson,	Greenfield,	Pleasant Street.
Hazen, Edward Leonard,	Springfield,	Care of E. H. Forristall.
Hebard, Emory Blodgett,	Southbridge,	3 Fearing streets.
Heffron, Fred,	Sherborn,	47 Pleasant Street.
Higgins, Edward William,	Arlington,	79 Pleasant Street.
Hogg, Lawrence Jagger,	Lawrence,	9 Phillips Street.
Howard, Louis Phillips,	North Easton,	82 Pleasant Street.
Hutchinson, John Gouvernour,	Arlington,	79 Pleasant Street.
Hutchinson, Raymond Ernest,	South Hanson,	52 Pleasant Street.

Ingham, Earl Morris, . . .	Granby, . . .	6 Nutting Avenue.
Jacobs, Loring Humphrey, . . .	Wellesley, . . .	9 Fearing Street.
Jewett, Henry Dana, . . .	West Newton, . . .	Pleasant and Fearing Streets.
Johnson, Bernhard Pol, . . .	Boston, . . .	Walker's House.
Johnson, Rollin Eugene, . . .	Templeton, . . .	14 Kellogg Avenue.
Jones, Dettmar Wentworth, . . .	Melrose, . . .	Care of Mrs. Dyer, Phillips Street.
Keyes, Pearl Pease, . . .	North Amherst, . . .	North Amherst.
Kilbourn, Walter Goss, . . .	South Lancaster, . . .	82 Pleasant Street.
Kriebel, Addison Reiff, . . .	Norristown, Pa., . . .	Thompson House.
Leach, Benjamin Robert, . . .	Methuen, . . .	79 Pleasant Street.
Leete, Richard Fowler, . . .	Mount Kisco, N. Y., . . .	79 Pleasant Street.
Lemoine, Albert Zepherin, . . .	South Framingham, . . .	-
Levine, Henry Walter, . . .	Roxbury, . . .	13 East Pleasant Street.
Lewis, John Kirby, . . .	New Haven, Conn., . . .	58 Pleasant Street.
Lincoln, Murray Danforth, . . .	North Raynham, . . .	82 Pleasant Street.
Lucas, Hoyt Dennis, . . .	West Springfield, . . .	6 Nutting Avenue.
MacDonald, Daniel Alfred, . . .	Walpole, . . .	79 Pleasant Street.
MacHale, William Edward, . . .	Jamaica Plain, . . .	-
Mahan, Harold Butteworth, . . .	Hingham, . . .	3 McCellan Street.
Major, Joseph, . . .	Rutherford, N. J., . . .	58 Pleasant Street.
McNiff, Owen Augustine, . . .	Harvard, . . .	52 Pleasant Street.
Meloon, Ralph Reid, . . .	Lowell, . . .	Mount Pleasant.
Merkle, Frederick Grover, . . .	Amherst, . . .	East Street.
Morrison, Harold Ivory, . . .	Melrose, . . .	66 Pleasant Street.
Morse, Harold John, . . .	Townsend, . . .	Brooks Farm.
Munroe, Donald Mitchell, . . .	Huntington, N. Y., . . .	101 Pleasant Street.
Murray, John Kane, . . .	Winthrop, . . .	14 Kellogg Avenue.
Needham, Lester Ward, . . .	Springfield, . . .	Care of E. H. Forristall.
Nicolet, Tell William, . . .	Fall River, . . .	17 Fearing Street.
Nicolet, Theodore Arthur, . . .	Fall River, . . .	17 Fearing Street.
Nicoll, William, . . .	Glen Cove, N. Y., . . .	101 Pleasant Street.
Nissen, Harry, . . .	Rosindale, . . .	13 Fearing Street.
Norton, Leslie Howard, . . .	Brockton, . . .	19 Hallock Street.
Oertel, John Thomas, . . .	South Hadley Falls, . . .	Walker Hall.
Palmer, John Philip, . . .	Portsmouth, N. H., . . .	79 Pleasant Street.
Parker, Edwin Kenney, . . .	Northampton, . . .	5 McCellan Street.
Parker, Ervine Franklin, . . .	Poquonock, Conn., . . .	96 Pleasant Street.
Payne, Roland Alfred, . . .	Wakefield, . . .	North Amherst.
Peters, Chester Harry, . . .	Brown Station, N. Y., . . .	11 Cottage Street.
Petersen, Peverill Oscar, . . .	Concord, . . .	55 Pleasant Street.
Pigott, Edgar Royston, . . .	Winthrop, . . .	14 Kellogg Avenue.
Porter, Bennett Allen, . . .	Amherst, . . .	R. D. 1, No. 25, Amherst.
Powers, Richard Henry, . . .	Malden, . . .	Walker Hall.
Presley, Fred Young, . . .	Malden, . . .	Pleasant Street.
Priest, Roger Alexander, . . .	Littleton, . . .	15 Fearing Street.
Read, Frederick William, . . .	Boston, . . .	75 Pleasant Street.
Rees, Harry Launcelot, . . .	Monson, . . .	3 Fearing Street.
Reid, George Alexander, . . .	Worcester, . . .	58 Pleasant Street.
Robinson, Herbert Calvin, . . .	Haverhill, . . .	Walker Hall.
Russell, Alden Hesselstine, . . .	Watertown, . . .	16 Pleasant Street.
Sahr, Gabriel Arthur, . . .	Boston, . . .	30 North Prospect Street.
Sanford, Clarence Higgins, . . .	Allston, . . .	3 Fearing Street.
Sexton, George Patrick, . . .	Allston, . . .	Brooks Farm.
Shaylor, Fred Wright, . . .	Lee, . . .	120 Pleasant Street.
Sherman, Joel Powers, . . .	Hyannis, . . .	Walker Hall.
Sherman, Milton Francis, . . .	South Lincoln, . . .	17 Kellogg Avenue.
Shirley, John Newton, . . .	South Duxbury, . . .	30 North Prospect Street.
Simmons, George Walker, . . .	Boston, . . .	116 Pleasant Street.
Slein, Owen Francis, . . .	New Braintree, . . .	Brooks Farm.
Small, Francis Willard, . . .	North Truro, . . .	12 Hallock Street.
Smart, Herbert Leighton, . . .	Framingham, . . .	15 Hallock Street.
Smith, Leone Ernest, . . .	Leominster, . . .	44 Pleasant Street.
Smith, Leon Edgar, . . .	Brighton, . . .	13 Fearing Street.

Spencer, Ray Silsby,	West Burke, Vt.,	79 Pleasant Street.
Stevens, Arthur Eben,	Brockton,	109 Main Street.
Stewart, George Osborn,	Somerville,	79 Pleasant Street.
Strange, Sarah Josephine,	Marshfield,	Draper Hall.
Taft, Carl Mather,	Mendon,	15 Hallock Street.
Taft, Richard Craig,	Oxford,	75 North Pleasant Street.
Talbot, Rolfe Henry,	Brockton,	5 McCellan Street.
Tarbell, Munroe Gifford,	Brimfield,	R. J. Goldberg's.
Taylor, Arthur Wright,	Feeding Hills,	Nutting Avenue.
Taylor, Leland Hart,	Peabody,	3 McCellan Street.
Thurston, Arthur Searle,	Everett,	9 Fearing Street.
Tower, Alfred Leigh,	Sheffield,	North Pleasant Street.
Tsang, Oong Hyuen,	Shanghai, China,	26 Lincoln Avenue.
Upton, Ernest Franklin,	Salem,	15 Cottage Street.
Walker, Nathaniel Kennard,	Malden,	83 North Pleasant Street.
Walker, Raymond Philip,	Taunton,	120 Pleasant Street.
Ward, Talbot,	Hyde Park,	11 Cottage Street.
Warner, Raymond Winslow,	Sunderland,	Care of E. H. Forristall.
Webster, Louis Armstrong,	Blackstone,	15 Hallock Street.
Weigel, Arthur George,	Lawrence,	79 Pleasant Street.
Wheeler, Chester Eaton,	Lowell,	79 Pleasant Street.
Wheeler, Warren Gage,	Dedham,	56 Pleasant Street.
Whidden, Burton Clark,	Waltham,	79 Pleasant Street.
Whippen, Charles Warren,	Lynn,	79 Pleasant Street.
White, Samuel Alexander,	Boston,	19 Fearing Street.
Whorf, Paul Francis,	Dorchester,	Brooks Farm.
Williams, George Edmund,	Belchertown,	Belchertown.
Wing, John Govan,	Somerville,	Brooks Farm.
Wood, Henry Joseph,	Mendon,	15 Hallock Street.
Wooley, Harold Curtis,	Malden,	83 Pleasant Street.
Wright, Frank Vernon,	Salem,	79 Pleasant Street.
Young, Royal Bosworth, Jr.,	Roxbury,	108 Pleasant Street.
Total, 160.		

UNCLASSIFIED STUDENTS. — NOT CANDIDATES FOR A DEGREE.

Churchill, George Clarence,	Worcester,	15 Beston Street.
Critchett, Edward Russell,	Watertown,	Mount Pleasant.
DeMott, Henry Vroom,	Metuchen, N. J.,	2 Allen Street.
Eager, Samuel Warner,	Deerfield,	120 Pleasant Street.
Edwards, Charles Richmond,	Northampton,	-
Gilmore, Howard Pool,	Waban,	3 Allen Street.
Granger, Helen,	Amherst,	Draper Hall.
Greene, William Allan,	Elmwood,	Mount Pleasant.
Hall, Horace Whitney,	Newton Center,	Pleasant Street.
Leonard, Larnie,	Talladega, Ala.,	48 Pleasant Street.
Lynch, Frank John,	Holyoke,	75 Pleasant Street.
O'Brien, Daniel William,	Wayland,	Lover's Lane.
Phelps, Benjamin Austin, Jr.,	Northampton,	79 Pleasant Street.
Reed, Waldo Burt,	Springfield,	11 Beston Street.
Selkregg, Edwin Reimund,	North East, Pa.,	17 Fearing Street.
Sibley, Milton Lawrence,	Worcester,	-
Sohier, Fred Martin,	Concord,	26 McCellan Street.
Total, 17.		

SUMMARY BY CLASSES.

Graduate students,	15
Senior class,	47
Junior class,	87
Sophomore class,	110
Freshman class,	158
Unclassified,	17
	<hr/> 419
	<hr/> 434

GEOGRAPHICAL SUMMARY.

Massachusetts,	367
Connecticut,	17
New York,	18
New Jersey,	7
Rhode Island,	2
Maine,	2
New Hampshire,	3
Vermont,	6
Delaware,	2
Pennsylvania,	2
Georgia,	2
Alabama,	1
Iowa,	1
Missouri,	1
China,	3
Japan,	1
	<hr/> 434

SHORT COURSES.

SHORT COURSES — 1910.

WINTER COURSE STUDENTS.

Alcock, James Richard, North Amherst.
 Baggs, Milton Charles, Belchertown.
 Bahsler, Eugene, Dunstable.
 Barnes, Joseph C., Lanesborough.
 Belknap, Robert Sidney, Amherst.
 Bowditch, John P., Framingham.
 Bowser, Lydia Animia, Cohasset.
 Bradstreet, Albert C., Topsfield.
 Canlett, Thomas Griffith, Rockport.
 Clark, Emerson Leland, Milford, Conn.
 Channing, Hayden, Sherborn.
 Childs, Samuel Wellington, Deerfield.
 Cordes, Edward, Great Barrington.
 Cox, Harold Childs, Wakefield.
 Curtis, Elliot D., Bantam, Conn.
 Day, Harry Ney, West Stockbridge.
 Dow, Aaron William, Bolton.
 Dunn, Howard Waterman, Dorchester.
 Eastwood, John Robert, North Adams.
 Edmands, Thomas Roland, Newton.
 Gage, Earl Lyman, Gilbertville, N. Y.
 Gray, George Arthur, Beverly.
 Harris, George Browning, North Adams.
 Holcomb, Edmund Alfred, Simsbury, Conn.
 Hurd, Robert Otis, Westminster.
 Kenney, Ralph Hewes, Greenwich, N. Y.
 Ketchen, Harold Barnett, Belchertown.
 Killam, John, East Boxford.
 Koch, Mrs., Mabel Tyler, Bloomfield, Conn.
 Lanier, Sidney, Walpole.
 Lemoine, Arthur Alfred, South Framingham.
 Lewis, Albert, East Rockaway, N. Y.
 Marsh, Howard Clifton, Arlington.

Maurer, Frank Julius, Newton.
 McCarroll, Edward Loomis, Waban.
 McIntyre, George Henderson, Easthampton.
 O'Donnell, James Curran, Belchertown.
 Pardee, Edwin Curtis, Bolton.
 Pease, Willard Morris, Monson.
 Peck, Harold Frederick, Belchertown.
 Perham, John Franklin, Ludlow Center.
 Priest, Frederick Stimpson, Watertown.
 Puffer, Willis Reynolds, Concord.
 Sabine, George Kraus, Jr., Brookline.
 Sanderson, Leon Benjamin, Williamsburg.
 Scace, William, Pittsfield.
 Scott, Edwin Gould, Garfield, Wash.
 Searle, Edward, Southampton.
 Seaver, John Dwight, New Britain, Conn.
 Selkregg, Edwin Reimund, North East, Pa.
 Shaughnessy, Thomas Francis, Marlborough.
 Smith, John Anderson, South Westport.
 Smith, Ralph Gibbs, North Amherst.
 Supple, Mark Wellman, South Deerfield.
 Thompson, Paul Ellis, Brookline.
 Torrey, Lewis Edwin, Southbridge.
 Urann, Carl B., Sullivan, Me.
 Valentine, Francis Wadsworth, Boston.
 Valentine, Richard Kirk, Erie, Pa.
 Vetter, Rudolf, North Andover.
 Walker, Elbert Lionel, Savoy Center.
 Walker, Rena Lillis, Savoy Center.
 Warfield, Preston George, Buckland.
 Wheeler, George Oscar, Hudson.
 Young, Earl Leonard, South Hadley.

Total, 65.

POULTRY KEEPERS' COURSE.

Barnes, Joseph C., Lanesborough.
 Barnes, J. Edward, Athol.
 Bradley, Miss A. J., Boston.
 Chapin, E. C., Holyoke.
 Chase, L. B., Sunderland.
 Childs, Irving H., Deerfield.
 Childs, Prentis B., Waltham.
 Clement, Ralph, Richmond.
 Coulson, S., Cambridge.
 Crisand, Carl, Worcester.
 Day, H. I., West Stockbridge.
 Day, Irving N., South Hadley.

Dearden, James, Massachusetts.
 Dixon, Enslo S., Roxbury.
 Follett, Mrs. E. F., Boston.
 Fox, Harry M., Dracut.
 Heard, J. G., Dover.
 Hitchcock, C. N., Amherst.
 Holcomb, E. A., Simsbury, Conn.
 Howards, Mrs. H. J., New York, N. Y.
 Hutchinson, Wm. F., Sutton.
 Johnson, C. W., Southborough.
 Kendall, Mrs. H. I., Hadley.
 Ketchen, Harold B., Belchertown.

Lanier, Sidney, Walpole.
 Lawrence, Susan M., East Northfield.
 Lupien, Israel A., Barre.
 Martin, Henry L., Marblehead.
 Mendum, S. W., Amherst.
 Merrian, Etta L., East Northfield.
 Merrick, Dr. Sara N., Cambridge.
 Newton, Ward H., Athol.
 Osgood, Champion, Cohasset.
 Paine, Ralph D., Ludlow.
 Perry, Lawrence, Hingham.
 Terry, Leon, Springfield.
 Priest, Frederick, Watertown.
 Robinson, G. F., Somerville.

Sanderson, Leon B., Williamsburg.
 Sias, Arthur E., East Boston.
 Snell, Lewis P., Greenwich, N. Y.
 Soderborn, G. O., New Bedford.
 Stearns, John Warren, Sharon.
 Thomas, Alfred C., Lawrence.
 Tower, Eva L., Northfield.
 Vetter, Rudolf, North Andover.
 Walker, Elbert L., Savoy Center.
 Whaley, James Sidney, East Orange, N. J.
 Whitcomb, R. H., Amherst.
 Whitney, J. C., Newbury.
 Young, Earl L., South Hadley.

Total, 51.

BEEKEEPERS' COURSE.

Allen, G. H., Amherst.
 Browning, C. P., Orange.
 Burnett, Mrs. Harriet C., Natick.
 Chapin, Annie M., Melrose.
 Fleury, Joseph, Huntington.
 Gowans, Ethel, Hampton, Va.
 Graves, Charles, Haydenville.
 Heath, Mrs. Alice, Auburndale.
 Ives, Henry E., Westhampton.
 Lawrence, Susan M., East Northfield.

Martin, J. O., Wilbraham.
 Martindale, Gerald, Amherst.
 Maud, Lawrence C., Bristol.
 Morse, Josephine, South Lancaster.
 Mulligan, Mrs. Minna, Natick.
 Murch, Mary E., Melrose.
 Schmitz, Eugene, Greenwich, Conn.
 Sherman, Lillian A., Amherst.
 Torrey, E. T., Southbridge.

Total, 19.

SUMMER SCHOOL STUDENTS.

Abercrombie, Rev. R. H., Windsor.
 Adams, Faneuil, Brookline.
 Adams, Lena R., Worcester.
 Adams, Rebecca, Brookline.
 Allen, Mary E., Worcester.
 Allen, Thomas, Belchertown.
 Allis, Abbie L. G., Amherst.
 Ames, Fisher, Brookline.
 Ames, Rosalie, Brookline.
 Ayer, Addie M., Richford, Vt.
 Ayer, Elizabeth P., Newport, R. I.
 Bailey, Ethel M., Lancaster.
 Baker, Florence M., Amherst.
 Ball, Minnie, Amherst.
 Beckwith, Fanny Leigh, Plainfield, N. J.
 Belcher, S. Elizabeth, Worcester.
 Bigelow, Lucy M., Amherst.
 Boinstein, Sarah, New York, N. Y.
 Boinstein, Pauline, New York, N. Y.
 Boyer, M. Elmer, Lynn.
 Brandow, Melvin, Plymouth.
 Brandow, Mrs. Melvin, Plymouth.
 Britt, Emma, South Boston.
 Bromley, Mae H., Dorchester.
 Brooks, Laura J., Stoneham.
 Brown, S. Crissy, Stamford, Conn.
 Burdick, Catharine Stevens, Newport, R. I.
 Burgess, Louisa W., Dorchester Center.
 Burrage, Ruth Kilburn, Medford.
 Butcher, Gertrude, Boston.

Carruth, Frank E., Cohoes, N. Y.
 Chapman, Christine, Springfield.
 Channing, Hayden, Sherborn.
 Charlton, Emanuel C., Heath.
 Chase, Rev. L. B., Sunderland.
 Cheney, Hazel Chase, Amherst.
 Clark, Doris, North Amherst.
 Clark, Katherine, North Amherst.
 Clark, Ruth Zilpha, Amherst.
 Cochrane, A. L., Boston.
 Cole, Albert S., North Dartmouth.
 Cooledge, Kate A., Boston.
 Cota, Florence L., Worcester.
 Cox, Edward J., Newtonville.
 Cox, Eleanor L., Newtonville.
 Cox, Isabella L., Newtonville.
 Cox, John E., Newtonville.
 Crook, Charles M., Saundersville.
 Crooks, Mrs. Charles M., Saundersville.
 Cushman, Elizabeth, Harvard.
 Cushman, Martha A., Harvard.
 Cushman, Esther C., Providence, R. I.
 Daly, Margaret, Brushton, N. Y.
 Damon, E. Farnham, Concord Junction.
 Davies, Rev. D. F., Plainfield.
 Davis, Helen, Amherst.
 Davis, Helen I., Lynn.
 Davis, Lillian E., Boston.
 Davis, Marjorie, Sterling.
 Day, George Willis, Lynn.

Day, Mrs. George W., Lynn.
Derrick, Rev. Thomas H., Wellfleet.
Downing, Florence E., Everett.
Drinker, Florence L., Brooklyn, N. Y.
Drinker, Minnie F., Brooklyn, N. Y.
Eastman, Laura M., Winchendon.
Edds, Rev. Wm. T., Sag Harbor, N. Y.
Edwards, Arthur C., Bolton.
Eltzholtz, John W., Jacksonville, Ill.
Evans, Mr. E. R., Atlanta, N. Y.
Fay, Louise, Waltham.
Firmin, Mrs. M. A., Medford.
Ford, James, Cambridge.
Ford, Mrs. James, Cambridge.
France, William, Duxbury.
Fruean, Mary A., Dorchester Center.
Gage, Lucy Helen, West Medford.
Gardner, Adaline A., East Boston.
Gifford, Mrs. Alice B., Amherst.
Goodrich, Martha A., South Boston.
Goodnow, Edna M., Amherst.
Gould, Ella F., Brockton.
Graham, Carrie C., New Haven, Conn.
Granger, Helen, Amherst.
Graves, C. Edward, Hatfield.
Gurney, Florence W., ———.
Gurney, Ida B., Marion.
Haffenreffer, August, Jamaica Plain.
Hall, F. Josephine, Waltham.
Hall, Ida Estelle, Waltham.
Harding, Burchan, Mrs., New York
Hardon, Henry C., Newton.
Harrington, Clara B., Montague.
Harris, Mabel Everett, Cambridge.
Hayward, Lewis F., Holyoke.
Hawthorne, Elizabeth S., Dorchester.
Henizen, Henriette M., New York, N. Y.
Hersey, George Milbank, Boston.
Hewes, Elizabeth, Cambridge.
Hogan, Teresa G., Taunton.
Holbrook, Ella M., Dover.
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Honnay, May, Amherst.
Hough, Helen, Northampton.
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Knight, Howard Lawton, Washington, D. C.

Knight, Mrs. Howard Lawton, Washington,
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 Seymour, Mary F., Winsted, Conn.
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 Smith, Ethel M., Amherst.
 Smith, Mr. H. W., North Haven, Me.
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 Stevens, Clara E., Boston.
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 Stone, Mrs. James S., South Framingham.
 Sullivan, Nellie L., Three Rivers.
 Swett, Ethel S., Beverly.

Swing, M. Ella, Bridgeton, N. J.
 Tapley, W. Thorpe, Revere.
 Tobin, Ellen C., Lawrence.
 Towne, Mary E., Amherst.
 Turner, Mable E., North Reading.
 Vauthier, Mr. L. P. F., Halifax.
 Walden, Margaret C., Deerfield.
 Watkins, Fred H., Gilbertsville.
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 Wilson, Warren H., New York.
 Winder, John H., Jr., Coppahosic, Va.
 Winn, Annah, Westfield, N. J.
 Wo, S. P., Amherst.
 Yang, Y. O., Amherst.

Total, 227.

SUMMARY OF SHORT COURSES.

Winter Course Students.

Massachusetts,	53	Maine,	1
Connecticut,	5	Washington, D. C.,	1
New York,	3		—
Pennsylvania,	2		65

Summer School Students.

Massachusetts,	173	Washington, D. C.,	2
New York,	20	Illinois,	1
Connecticut,	8	Maine,	1
New Jersey,	8	Maryland,	1
Rhode Island,	4	Vermont,	1
Pennsylvania,	4		—
New Hampshire,	2		227
Ohio,	2		

Poultry Course.

Massachusetts,	47
New York,	2
Connecticut,	1
New Jersey,	1
	—
	51

Beekeepers.

Massachusetts,	18
Virginia,	1
	—
	19

UNREGISTERED ATTENDANTS.

Rural Conference of Social Workers.

Massachusetts,	289	Colorado,	1
New York,	13	Ohio,	1
Connecticut,	11	Maryland,	1
New Jersey,	5	Rhode Island,	1
New Hampshire,	4	Maine,	2
Vermont,	4	Illinois,	2
Pennsylvania,	4		—
Washington, D. C.,	3		341

Farmers' Week.

Massachusetts,	533	California,	1
Connecticut,	9	Montana,	1
Maine,	4	Michigan,	1
Rhode Island,	3	New Mexico,	1
New York,	3		—
New Hampshire,	2		559
Vermont,	1		

Correspondence Courses.

Massachusetts,	360
--------------------------	-----

227
65
61
219

362

11

439
227

671

65
57
19
227
362
439
716

SECRETARIES OF ALUMNI ASSOCIATIONS AND CLASSES.

Alumni Secretaries' Association of the Massachusetts Agricultural College.

Secretary: RALPH J. WATTS, 1907, Amherst, Mass.

Associate Alumni of the Massachusetts Agricultural College.

Secretary: SIDNEY B. HASKELL, 1904, Amherst, Mass.

Local Alumni Association of the Massachusetts Agricultural College.

Secretary: SIDNEY B. HASKELL, 1904, Amherst, Mass.

Alumni Club of Massachusetts.

Secretary: HERBERT W. DANA (1899), Care of R. H. White Company, Boston, Mass.

Connecticut Valley Association of the Massachusetts Agricultural College.

Secretary: WALTER B. HATCH, 1905, Torrington, Conn.

Massachusetts Agricultural College Club of New York.

Secretary: JOHN ASHBURTON CUTTER, 1882, 262 West 77th Street, New York, N. Y.

Massachusetts Agricultural College Club of Washington, D. C.

Secretary: CLARENCE H. GRIFFIN, 1904, 3438 Mount Pleasant, Washington, D. C.

Western Alumni Association of the Massachusetts Agricultural College.

Secretary: CHARLES A. TIRRELL, 1906, 4012 Perry Street, Chicago, Ill.

Massachusetts Agricultural College Pacific Coast Alumni Association.

Secretary: THOMAS F. HUNT, 1905, Berkeley, Cal.

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1872	S. T. Maynard, . .	Northborough, Mass.
1873	C. Wellington, . .	Amherst, Mass.
1874	— — — —	— — — —
1875	M. Bunker,	Newton, Mass.
1876	C. Fred Deuel, . . .	Amherst, Mass.
1877	— — — —	— — — —
1878	C. O. Lovell,	48 Summer Street, Boston, Mass.
1879	R. S. Swan,	Worcester, Mass.
1880	— — — —	— — — —
1881	J. L. Hills,	Burlington, Vt.
1882	G. D. Howe,	Bangor, Me.
1883	J. B. Lindsey, . . .	Amherst, Mass.
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1885	E. W. Allen,	Washington, D. C.
1886	Dr. Winfield Ayres, .	616 Madison Avenue, New York, N. Y.
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1889	C. S. Crocker,	25 South Van Pelt Street, Philadelphia, Pa.
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1891	H. T. Shores,	Northampton, Mass.
1892	H. M. Thomson, . . .	Amherst, Mass.
1893	F. A. Smith,	Ipswich, Mass.
1894	S. F. Howard,	Amherst, Mass.
1895	H. A. Ballou,	Barbadoes, W. I.
1896	— — — —	— — — —
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1898	— — — —	— — — —
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1901	J. H. Chickering, . .	Dover, Mass.
1902	H. L. Knight,	1731 T Street, Washington, D. C.
1903	G. D. Jones,	North Amherst, Mass.
1904	P. F. Staples,	North Grafton, Mass.
1905	P. F. Williams,	Auburn, Ala.
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1910	Henry T. Cowles, . . .	Central High School, Santurce, P. R.

INDEX.

	PAGE		PAGE
Admission	25-40	Horticulture	58, 90
Advanced standing	39	Humanities	64
Agricultural education	44	Hygiene	78
Agriculture	45		
Agronomy	46	Itinerant instruction	106
Animal husbandry	47		
Attendance, summary of	154	Journalism	65
Awards. (See Honors.)			
		Landscape gardening	61
Bacteriology	82	Languages, modern European. (See	
Botany	50, 90	French, German, Spanish.)	
		Library	125
Calendar	7	Literature	64-69, 70-72, 82
Certificates, admission on	25		
Chemistry	52, 90	Market gardening	63
Civil engineering	74, 76	Massachusetts Agricultural College	9
Clubs, etc.	129-131	Massachusetts Agricultural Experi-	
College officers	14-17	ment Station	11
Committees of faculty	21	Mathematics	74
Corporation	12	Military science	76
Courses of instruction:		Music	72
Undergraduate	41-84		
Graduate	85-94	Organizations, student	129
Dairying	48	Physical education	78
Degrees conferred	135	Physics	74-76
Dormitories	115	Political science	72
Drawing	63	Pomology	60
		Prizes	118-120
Economics,	72-73, 79-81	Public speaking	68
English	64-69		
Entomology	57, 90	Religious services	129
Entrance. (See Admission.)		Roll of students	137
Equipment of departments	120	Rural social science	79
Examinations, entrance. (See Ad-			
mission.)		Scholarships	118
Expenses	115	Short courses. (See Extension Work.)	
Experiment station	11, 18	Sociology	73
Extension work	95	Spanish	70
		Student expenses	115
Faculty	14	Students, roll of	137
Faculty committees	21	Summer school	102
Farm administration	49		
Fellowships. (See Scholarships.)		Table of undergraduate subjects	41-43
Floriculture	60	Trustees, etc.	12
Forestry	63		
French	69	Unclassified students	40
		Undergraduate courses	41-84
General information	113-131		
Geology	84	Veterinary science	82
German	71		
Government	72	Winter school	99
Graduate school	85		
		Zoölogy	83, 90
History	73-74		
Honors	131		

TWENTY-THIRD ANNUAL REPORT
OF THE
MASSACHUSETTS AGRICULTURAL
EXPERIMENT STATION.

PART I.,
BEING PART III. OF THE FORTY-EIGHTH ANNUAL REPORT
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JANUARY, 1911.



BOSTON:
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THE STATE BOARD OF PUBLICATION.

TWENTY-THIRD ANNUAL REPORT

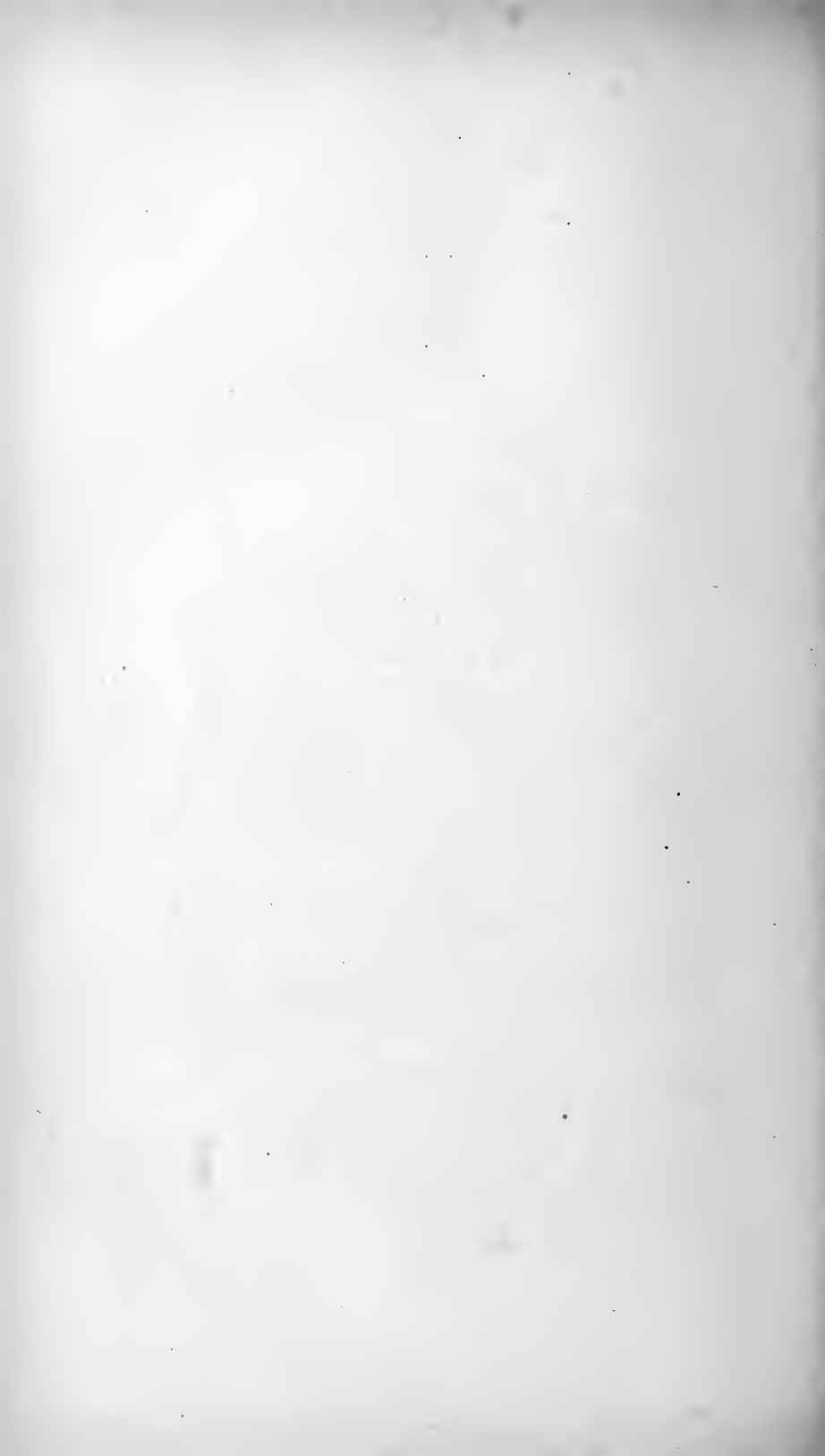
OF THE

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

PART I.

DETAILED REPORT OF THE EXPERIMENT STATION.



INTRODUCTION.

In accordance with the provision of the act of the Legislature relative to the publication of the reports of the Massachusetts Agricultural College, the report of the experiment station, which is a department of the college, is presented in two parts. Part I. contains the formal reports of the director, treasurer and heads of departments, and papers of a technical character giving results of experiments carried on in the station. This will be sent to agricultural colleges and experiment stations and to workers in these institutions, as well as to libraries. Part I. will be published also in connection with the report of the Secretary of the State Board of Agriculture, and will reach the general public through that channel. Part II. will contain papers of a popular character, and will be sent to persons on our mailing list.

WM. P. BROOKS,
Director.

CONTENTS.

PART I.

	PAGE
Station organization,	11
Report of the director,	13
Changes in staff,	13
Lines of work,	16
Dissemination of information,	16
Publications,	16
Publications during 1910,	16
Publications available for free distribution,	17
Circulation of publications,	18
Correspondence,	20
Lectures and demonstrations,	20
Future provision for extension work,	20
General experiments,	21
Co-operative experiments with alfalfa,	22
Research,	23
Asparagus substation, Concord,	24
Breeding experiments,	24
Fertilizer experiments,	25
Chemical work on asparagus roots,	25
Cranberry substations,	26
Fertilizer experiments,	27
Insect work,	28
Control work,	28
Fertilizer law,	28
Dairy law,	29
Feed law,	29
Inspection of apiaries,	30
Buildings,	30
Report of the treasurer,	32
Report of the agriculturist,	34
Comparison of different materials as a source of nitrogen,	34
Muriate compared with sulfate of potash,	36
Nitrogen fertilizers and potash salts for garden crops,	38
Relative value of different potash salts,	40
Comparison of different phosphates,	42
Manure alone compared with manure and sulfate of potash,	44
Average corn fertilizer compared with fertilizer richer in potash,	45
South acre soil test,	46

	PAGE
Report of the agriculturist — <i>Con.</i>	
North acre soil test,	47
Top dressing for hay,	48
Winter <i>v.</i> spring application of manure,	49
Report of the chemist,	51
Correspondence,	51
Numerical summary of work in chemical department,	51
Laboratory work of the research section,	52
Research work in animal nutrition,	53
Tabulations,	53
Report of the fertilizer section,	54
Fertilizers licensed,	54
Fertilizers collected,	55
Fertilizers analyzed,	55
Trade values of fertilizer ingredients,	56
Summary of analyses and guarantees of licensed complete fertilizers,	57
Commercial shortages,	59
Quality of plant food,	60
Grades of fertilizer,	60
Composition according to grade,	61
Unmixed fertilizers,	63
Miscellaneous substances,	63
Nitrogen compounds,	65
Potash compounds,	65
Phosphoric acid compounds,	66
Miscellaneous work,	66
Report of the feed and dairy section,	67
The feed law,	67
Analytical work,	67
Compliance with the law,	68
New law,	68
Definitions,	69
Weight of sacked feeds,	69
The dairy law,	69
Examination of candidates,	69
Examination of glassware,	70
Inspection of Babcock machines,	70
Creameries,	71
Milk depots,	72
Milk, cream and feeds sent for free examination,	72
Analysis of drinking water,	72
Miscellaneous work,	73
Testing of pure bred cows,	74

	PAGE
Report of the botanist,	75
Diseases more or less common during the year,	75
Report of the entomologist,	77
Goessmann, Charles A., tribute to,	80
Studies in milk secretion,	86
The effect of protein upon the production and composition of milk,	86
The determination of arsenic in insecticides,	122
Methods,	122
Iodine method,	124
New processes,	125
Practice at Massachusetts station,	127
Iodine methods for arsenates,	129
Purification of insoluble fatty acids,	131
Distillation of the fatty acids in vacuo,	131
Crystallization from alcohol,	132
Distillation of the ethyl esters in vacuo,	133
The soluble carbohydrates in asparagus roots,	135
Seed work, 1910,	141
An outbreak of rusts,	144
Sweet pea troubles,	145
A spinach disease new to Massachusetts,	146
Abnormalities of stump growths,	149
Description of mosaic disease,	150
Relation to mosaic disease,	154
Experiments in inoculation,	154
Relation of root area to intensity of disease,	156
Chemical tests of abnormal leaves,	157
Conclusions,	159
Peach and plum troubles,	161
Brown rot, scab, gummosis, etc.,	161
Climatic adaptations of apple varieties,	177
I. Introduction,	177
II. The causes of varietal variation,	179
Cultural variation,	179
Soil variation,	180
Climatic variation,	180
The mean summer temperature,	182
III. The development of the apple,	183
IV. The perfectly developed apple,	186
V. The individuality of the tree,	194
VI. The modifying effect of climate on the development of the apple,	199
On form,	199
On size,	204

Climatic adaptations of apple varieties — *Con.*VI. The modifying effect of climate on the development of the apple — *Con.*

On general development,	205
Apple belts in North America,	205
Distribution of varieties,	207
The relation of temperature to development,	221
The mean summer temperature,	221
The winter minimum,	221
The heat of summer,	222
The effect of low and of high mean summer temperatures,	222
The optimum mean summer temperature,	227
Chemical determinations,	232

VII. Summary, 243

Compilations,	246
Analyses of fodder articles and dairy products,	247
Composition and digestibility of fodder articles,	249
Fertilizer ingredients of fodder articles,	266
Analyses of dairy products,	272
Coefficients of digestibility of American fodder articles,	273
Analyses of agricultural chemicals, refuse salts, phosphates, guanos, ashes, lime compounds, marls, by-products, refuse substances and animal excrements,	304
Chemicals and refuse salts,	306
Phosphates and guanos,	308
Ashes, lime compounds and marls,	310
By-products and refuse substances,	314
Animal excrements,	322
Insecticides,	323
Analyses of fruits and garden crops,	324
Fruits,	325
Garden crops,	327
Relative proportions of phosphoric acid, potassium oxide and nitrogen in fruits and garden crops,	334
Composition of some Massachusetts soils,	339
Description of types,	339
Miscellaneous soil analyses,	341
European standards for comparison,	346

MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, MASS.

TWENTY-THIRD ANNUAL REPORT.

PART I.

ORGANIZATION.

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J. LEWIS ELLSWORTH.
ARTHUR H. POLLARD.
CHARLES E. WARD.

HAROLD L. FROST.
THE PRESIDENT OF THE COLLEGE, *ex officio*.
THE DIRECTOR OF THE STATION, *ex officio*.

Station Staff.

WILLIAM P. BROOKS, Ph. D., Director, 28 Northampton Road.
JOSEPH B. LINDSEY, Ph. D., Vice-Director, 47 Lincoln Avenue.
FRED C. KENNEY, Treasurer, Mount Pleasant.
CHARLES R. GREEN, B.Agr., Librarian, Mount Pleasant.

Department of Plant and Animal Chemistry.

JOSEPH B. LINDSEY, Ph.D., Chemist, 47 Lincoln Avenue.
EDWARD B. HOLLAND, M.Sc., Associate Chemist, in charge of Research Division, 28 North Prospect Street.
FRED W. MORSE, M.Sc., Research Chemist, 44 Pleasant Street.
HENRI D. HASKINS, B.Sc., In charge of Fertilizer Section, 87 Pleasant Street.
PHILIP H. SMITH, B.Sc., In charge of Feed and Dairy Section, 102 Main Street.
LEWELL S. WALKER, B.Sc., Assistant, 19 Phillips Street.
JAMES C. REED, B.Sc., Assistant, Nutting Avenue.
JOSEPH F. MERRILL, B.Sc., Assistant, North Prospect Street.
CLEMENT L. PERKINS, B.Sc., Assistant, 32 North Prospect Street.
JOSEPH P. HOWARD, Collector, North Amherst, Mass.
HARRY J. ALLEN, Laboratory Assistant, 89 Main Street.
JAMES R. ALCOCK, Assistant in Animal Nutrition, North Amherst, Mass.

Department of Agriculture.

WILLIAM P. BROOKS, Ph.D., Agriculturist, 28 Northampton Road.
H. J. FRANKLIN, Ph.D., In charge of Cranberry Investigation, Wareham, Mass.
ERWIN S. FULTON, B.Sc., First Assistant, North Amherst, Mass.
EDWIN F. GASKILL, B.Sc., Second Assistant, North Amherst, Mass.

Department of Horticulture.

FRANK A. WAUGH, M.Sc., Horticulturist, Massachusetts Agricultural College.

FRED C. SEARS, M.Sc., Pomologist, Mount Pleasant.

JACOB K. SHAW, M.Sc., Assistant Horticulturist, 1 Allen Street.

DAVID W. ANDERSON, B.Sc., Graduate Assistant, 32 North Prospect Street.

Department of Botany and Vegetable Pathology.

GEORGE E. STONE, Ph.D., Botanist and Vegetable Pathologist, Mount Pleasant.

GEORGE H. CHAPMAN, M.Sc., Assistant Botanist, 13 Fearing Street.

SUMNER C. BROOKS, B.Sc., Assistant Botanist, 28 Northampton Road.

Department of Entomology.

HENRY T. FERNALD, Ph.D., Entomologist, 44 Amity Street.

BURTON N. GATES, Ph.D., Apiarist, 42 Lincoln Avenue.

ARTHUR I. BOURNE, B.A., Assistant in Entomology, 66 North Pleasant Street.

Department of Veterinary Science.

JAMES B. PAIGE, B.Sc., D.V.S., Veterinarian, 42 Lincoln Avenue.

Department of Meteorology.

JOHN E. OSTRANDER, A.M., C.E., Meteorologist, 35 North Prospect Street.

CHARLES M. DAMON, Observer, Massachusetts Agricultural College.

Other Officers of the Experiment Station.

Miss ROSE J. BROWN, Secretary to the Director, Draper Hall.

Miss JESSIE V. CROCKER, Stenographer, Department of Botany and Vegetable Pathology, Sunderland, Mass.

Miss HARRIET COBB, Stenographer, Department of Plant and Animal Chemistry, 35 North Pleasant Street.

Miss BRIDIE O'DONNELL, Stenographer, Department of Entomology, Hadley, Mass.

Miss ALICE M. HOWARD, Stenographer, Department of Plant and Animal Chemistry, North Amherst, Mass.

REPORT OF THE DIRECTOR.

CHANGES IN STAFF.

The experiment station staff during the past year has suffered the loss of two of its oldest and strongest men: Dr. C. A. Goessmann, who died in September, and Dr. C. H. Fernald, who retired on a Carnegie pension at about the same time.

Dr. Goessmann had been connected with the experiment station from the very first inception of station work in the State, in 1882. He was director of the State Experiment Station until it was combined with the station later organized under the Hatch act, in 1895. Dr. Goessmann, however, although giving up his duties as director at that time, retained active supervision of the inspection of commercial fertilizers and the general work in the fertilizer and soil laboratory until his retirement in 1907. Subsequent to retirement he was retained as consulting chemist, and continued his active interest in the station and its work until almost the end of his life. Goessmann was one of the great pioneers in the work of agricultural investigation. It seems eminently fitting, therefore, to present at this time a brief account of his life and work. Dr. J. B. Lindsey, vice-director and chemist of the station, one of Dr. Goessmann's pupils, peculiarly fitted through long and close association with him to write such an account and estimate, has at my request kindly prepared a tribute which will be found in following pages.

Dr. Charles H. Fernald, head of the entomological department of the college and station, became connected with the station work at the time of organization under the Hatch act, and continued at the head of the entomological department until his retirement, the first of September last. Dr. Fernald's work was of great value to the station. Of him, as of Goessmann, it is largely true that to a considerable extent his work was of a pioneer character. He was one of the earliest station entomologists, and as such he had much to do with the establishment of a

general policy for station entomological work. It was in considerable measure due to his influence that the policy that original descriptions of insects should not be published in ordinary station bulletins was adopted. During the early years of his station activities he devoted a large amount of time to the study of the gypsy moth, and the recognition of this insect and the scientific work connected with it were due to his efforts. His work in connection with the gypsy moth greatly strengthened the entomological department of the station, and resulted in making its work better understood and appreciated. Dr. Fernald's bulletin on household insects is believed to have been the first of its kind; but the value of such work was promptly recognized. His monograph papers, which have been published as station bulletins, are constantly quoted as standard works on the subjects of which they treat. He was the first to undertake investigations on cranberry insects, and the work he did in relation to them proved of great value to cranberry growers. His work in systematic and economic entomology has been extensive, and he instituted numerous lines of investigation which have since been greatly extended and developed by others better situated to prosecute them. While Professor Fernald did a very large amount of strong original work, I think it will be generally admitted by those who know him and his influence that his greatest work was in the line of stimulating others by his personality to accomplish what he himself had no opportunity to do.

The death of Dr. Goessmann did not involve important changes in the chemical department as his services during the past few years had been simply advisory, and, owing to failing health, largely nominal during the last year or two.

On the retirement of Dr. C. H. Fernald, his son, Dr. H. T. Fernald, was made head of the entomological department. The retirement of the elder Fernald imposed additional duties on his son, and some reorganization of the department became necessary. Mr. John N. Summers, a graduate assistant, who had been giving one-half his time to the experiment station, retired, and in his place, Mr. A. I. Bourne, B. A., who has had a valuable experience in graduate and investigational work, was made assistant. Mr. Bourne is allowed a certain amount of time for

graduate study, but he will give nearly all his attention to the work in the experiment station. His employment relieves Dr. H. T. Fernald of almost all of the routine work of the entomological department, and of the necessity of giving direct personal attention to the experimental work in its simpler phases. This will make it possible for Dr. Fernald to devote a very large proportion of his time to research work in entomology.

In this connection attention should be called to the extremely valuable work which Mrs. C. H. Fernald, with some clerical assistance, carried on for a period of more than twenty years, in editing the index cards with references to entomological literature. The work of Mrs. Fernald has been characterized by extreme accuracy and thoroughness, and up to the present time no less than 50,000 cards, with many times that number of references, have been prepared. A large proportion of the entries on these are in Mrs. Fernald's own hand. Advancing years have led Mrs. Fernald to desire to be relieved of this work, so important to all investigators in all lines of entomology, and arrangements have been completed whereby it will be continued under Dr. H. T. Fernald's supervision by his stenographer and clerk, Miss O'Donnell.

The retirement of Dr. R. D. MacLaurin, referred to in my last annual report, left a vacancy in the research division of the chemical department. This place was filled in January by the temporary appointment of Fred W. Morse, Ph.D., for many years chemist of the New Hampshire Experiment Station. His appointment was made permanent in July. Mr. Morse is devoting himself entirely to research problems connected with the nutrition of crops and the productive capacity of soils.

The staff of the station has been strengthened by the addition of two men; David W. Anderson, B.Sc., has been made graduate assistant in the department of horticulture; Sumner C. Brooks, B.Sc., has been made assistant in the department of botany and plant pathology. The appointment of these men relieves their superiors in these departments of routine work, and will enable them to devote their time in larger measure to research.

The work of the station has been broadened in scope and fur-

ther strengthened by the appointment of Dr. B. N. Gates, Ph.D., as apiarist. It is the expectation that Dr. Gates will devote about one-quarter of his time, so far as possible consecutively, to research work on problems connected with beekeeping.

Mr. James Alcock replaces Mr. Roy Gaskill in charge of the animals used in feeding and digestion experiments, and Clement L. Perins, B.Sc., has taken the place of Carl D. Kennedy as assistant in the chemical laboratory.

LINES OF WORK.

There has been no essential change in the character of station work during the year. It covers a field of constantly broadening scope and increases steadily in amount. As heretofore, our efforts may be classed under the following principal heads: general experiments, research, control and dissemination of information.

The relation of the lines of work which come under the last class to the possibility of adequate attention to and of financial support for the experiment and research, for carrying on which the funds for the support of the station which come from the federal government are designed, is so vital that while in logical sequence these lines of work would seem to come last, they will be considered first.

DISSEMINATION OF INFORMATION.

The principal methods whereby the station now endeavors to serve the public by dissemination of information are by means of its publications, through private correspondence, through lectures by members of its staff and by demonstrations.

Publications. — Our publications are of three kinds, an annual report in two parts, bulletins and circulars. The following tables show the publications of the year 1910 and those still available for distribution: —

Publications during 1910.

Annual report: —

Parts I. and II. 338 pages.

Bulletins: —

No. 132. Inspection of Commercial Feed Stuffs, P. H. Smith and J. C. Reed. 64 pages.

- No. 133. Green Crops for Summer Soiling, J. B. Lindsey. 20 pages.
No. 134. The Hay Crop, William P. Brooks. 68 pages.
No. 135. Inspection of Commercial Fertilizers, H. D. Haskins, L. F. Walker and J. F. Merrill. 76 pages.

Meteorological bulletins, 12 numbers. 2 pages.

Circulars:

- No. 26. Fertilizers for Potatoes, William P. Brooks. 4 pages.
No. 27. Seeding Mowings, William P. Brooks. 8 pages.
No. 28. Rules relative to Testing Dairy Cows. 8 pages.
No. 29. Chemical Analysis of Soils, William P. Brooks. 4 pages.

Miscellaneous circulars (unnumbered): —

- Fertilizers for Corn, William P. Brooks. 2 pages.
Home-mixed Fertilizers, William P. Brooks. 4 pages.
Fertilizers for Turnips, Cabbages and Other Crucifers, William P. Brooks. 2 pages.
Dairymen losing Money on Low-grade Feeds, J. B. Lindsey. 2 pages.
Orchard Experiment, William P. Brooks. 2 pages.
Summer Soiling Crops, P. H. Smith. 1 page.
Balanced Rations for Business Cows, J. B. Lindsey. 2 pages.
Corn for the Silo. 2 pages.

Publications Available for Free Distribution.

Bulletins: —

- No. 33. Glossary of Fodder Terms.
No. 68. Fertilizer Analyses.
No. 76. The Imported Elm-leaf Beetle.
No. 83. Fertilizer Analyses.
No. 84. Fertilizer Analyses.
No. 89. Fertilizer Analyses.
No. 90. Fertilizer Analyses.
No. 103. Fertilizer Analyses.
No. 113. Fertilizer Analyses.
No. 115. Cranberry Insects.
No. 121. Seed Separation and Germination.
No. 123. Fungicides, Insecticides and Spraying Directions.
No. 124. Bee Diseases in Massachusetts.
No. 125. Shade Trees.
No. 126. Insects Injurious to Cranberries and how to fight them.
No. 127. Inspection of Commercial Fertilizers, 1908.
No. 130. Meteorological Summary — Twenty Years.
No. 131. Inspection of Commercial Fertilizers, 1909.
No. 132. Inspection of Commercial Feed Stuffs, 1910.
No. 133. Green Crops for Summer Soiling.
No. 134. The Hay Crop.
No. 135. Inspection of Commercial Fertilizers, 1910.

No. 136. Inspection of Commercial Feed Stuffs, 1911.

Technical Bulletin No. 2. The Graft Union.

Technical Bulletin No. 3. The Blossom End Rot of Tomatoes.

Index to bulletins and annual reports of the Hatch Experiment Station previous to June, 1895.

Index to bulletins and annual reports, 1888-1907.

Annual reports: 10th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 20th, 21st, Part II., 22d, Parts I. and II.

So far as our publications treat primarily of the results of station observation, experiment and research, they are to be looked upon as a necessary and important feature of station activity, — indeed, to be the crowning result of such activity; but the demand for bulletins and circulars of information of a general character, already widespread, is most active, insistent and growing, and the force of circumstances has seemed to compel us to make at least some effort to meet it. To fully do so has been impossible; indeed, must probably be recognized as in the very nature of things always likely to remain so, since nothing less than a complete library covering every conceivable agricultural topic would enable us to meet the demand.

A considerable share of the contents of the popular part of our annual report (Part II.), most of our circulars and some of our bulletins have, however, aimed to furnish information of a more or less general character on topics of immediate interest to the public. These papers have, it is true, been based upon our own observations and experiments in so far as possible, and to that extent are to be regarded as legitimate station publications. To a considerable extent, however, they are of a general character. United States funds cannot be used in their publication, and since the demands for other purposes upon the relatively small appropriation which comes to the station from the State are heavy, and since, further, furnishing this literature is rather extension than experiment, provision to carry the costs should be made in the extension department of the institution.

Circulation of Publications. — In accordance with an act of our Legislature Part I. of our annual report is printed with the report of the secretary of the State Board of Agriculture, and those on the mailing list of that Board will receive this publication. Five thousand copies of Part I. of our annual report also

are furnished to the station. These are sent to libraries and directors of agricultural experiment stations, to presidents and libraries of agricultural colleges, to the public libraries of Massachusetts, and all other libraries on our mailing list, to the mailing list of the United States Department of Agriculture and to those on our exchange list. This part of our annual report contains technical monographs giving the results of research work, and a large number of copies are reserved to meet future demands. Part II. of our annual report, which contains the more popular papers, and our bulletins are sent to all those on our general mailing list, to the public libraries of the State, to those on the mailing list of the United States Department of Agriculture likely to be interested, and to experiment stations and agricultural colleges. It is our aim to reserve a considerable number of each publication to meet subsequent demands, but the demand has grown so rapidly that the supply of most, as will be noted from the above list of available publications, has been exhausted. The meteorological bulletins are sent only to agricultural college and experiment station libraries, presidents and directors, to the Department of Agriculture and Office of Experiment Stations, to newspapers and to libraries and individuals who have especially requested them.

Our circulars are printed for use in connection with the correspondence of the station. It is only by the use of such circulars that we are able to give information and advice on the many problems on which we are consulted. These circulars are sent only as above stated or on request. An abstract of all important publications is furnished to the press, and requests for any issued will be met as long as the supply permits.

During the past year the revision of our general mailing list has been completed. As a result, 1,502 names were dropped from the list. The additions of the year have numbered 1,663 names. The total numbers on our general list and on the few special lists are shown by the following: —

Residents of Massachusetts,	. . . . .	13,361
Residents of other States, .	. . . . .	2,381
Residents of foreign countries, .	. . . . .	223
Newspapers,	. . . . .	524

Libraries,	292
Exchanges,	137
Cranberry growers,	1,437
Beekeepers,	2,638
Meteorological,	379

Correspondence. — The correspondence with private individuals who seek information or advice grows constantly and rapidly. During the year 1910 the number of letters of inquiry answered by the members of the station staff was 16,650. Replies to many of these involve investigation, and the demands upon the college and station men giving attention to this work are heavy and growing. There can be no doubt that such work is most helpful; numerous letters of appreciation testify to this fact. The work should be continued, but it is neither experiment nor research. It is rather a branch, and a most important one, of the extension propaganda, and should be provided for in that department.

Lectures and Demonstrations. — The demand for lectures and demonstrations by members of the station staff has much increased during the year. Relatively few of the requests for such services have been accepted. The number of such engagements met during the year has been 48. Work of this kind properly comes under the head of extension service, and yet as it helps in some measure to keep the station men, whose duties are for the most part of a character which keeps them closely confined, in touch with the public and its most vital problems, these opportunities are accepted in so far as is consistent with proper attention to the prosecution of those investigations and studies for which especially the station is maintained.

Future Provision for Extension Work. — The facts stated concerning the various lines of work which have for their object the dissemination of information must have made it apparent that this work now makes very heavy demands upon the time of station men. It already encroaches upon resources which would more properly be devoted to experiment and research. The authorities in Washington charged with the general oversight of the methods of expenditure of United States funds are most zealous, and rightly so, in their efforts to pre-

vent the diversion of these funds from the uses for which they are intended. The funds appropriated to the station by the State are not sufficient to cover this line of work and at the same time to provide funds to pay the costs of other lines of work now in progress which should be continued.

The desired relief may be obtained either by transfer of the lines of work under consideration to the extension department of the institution, or by the appropriation of funds from that department to cover the cost of employing competent secretarial assistants. The latter plan would, for a time at least, seem to have advantages, as with secretarial assistance the members of the station departments whose experience gives them the best foundation for it would be able to direct the work and to exercise a close oversight over it.

GENERAL EXPERIMENTS.

Under this class are included a large number of experiments relative to the following subjects: soil tests with fertilizers, with different crops in rotation; comparisons of different materials which may be used as sources, respectively, of nitrogen, phosphoric acid and potash for different field and garden crops; the results of the use of lime; systems of fertilizing grass lands, both mowings and pastures; comparisons of fertilizers for both tree and bush fruits; different methods of applying manures; variety tests of field and garden crops and of fruits; trials of new crops; determinations of the digestibility of feedstuffs; methods of feeding for milk; systems and methods of management in feeding poultry for eggs; and co-operative work with selected farmers in the trial of crops and systems of fertilizing them. Few of these lines of experiment call for special comment here. Brief reports on some of them will be found under the departments in which they are being prosecuted.

Particular attention is directed to the fact that the plots used in the various experiments, involving the highly varied use of manures and fertilizers, and the many comparisons in progress, become increasingly valuable with the passing years. Many of these plots have been under definite and differing

manurial treatment for periods of time ranging from twelve to twenty-one years. They have taught many important lessons. If undisturbed, they will teach many more. They are teaching new lessons yearly as to the ultimate effects of differing treatments.

These facts are pointed out because the development of the institution on its educational side appears to threaten the integrity of important series of plots. They cannot, of course, be moved, nor indeed, in any true sense, can they be replaced. It is urged, therefore, that their value and the extreme undesirability of disturbing them be recognized in all plans for future growth and development.

Co-operative Experiments with Alfalfa. — During the past year thirty-three experiments with alfalfa have been made in ten different counties. Arrangements were completed for one experiment also in each of the counties Barnstable, Bristol and Dukes, but local conditions prevented the carrying out of the plans formed. Northern-grown seed treated with farm-germ for inoculation with nitrogen-fixing bacteria was used. The following extract from the directions sent to co-operating farmers will indicate what is believed to be a satisfactory method of preparing for the crop: —

(1) Plow in spring just as soon as possible after the ground can be worked.

(2) Apply lime at the rate of about $1\frac{1}{2}$ tons to the acre and disk in at once.

(3) About ten days later apply the following mixture per acre: basic slag meal, 1,500 pounds, high-grade sulfate of potash, 400 to 500 pounds, and disk that in.

(4) Thereafter harrow about once in ten to twelve days, until you are ready to sow the seed, which should not be later than about July 27.

(5) When ready to sow the seed, apply per acre: nitrate of soda, 100 pounds, basic slag meal, 300 pounds, mixing them, and harrowing in lightly.

(6) Sow 30 pounds of seed per acre, in showery weather if possible, and cover as you would grass seed.

The fall months were exceptionally dry and therefore somewhat unfavorable, but in most cases the crops made a good start

and went into the winter in good condition, having made sufficient growth to afford the needed protection.

RESEARCH.

More research work has been done in the station during the past year than in any previous year of its history. The additions to our staff which have made this possible have already been referred to. Work still continues upon the various research problems which have been mentioned in earlier reports,¹ but the studies of *Pyrilidæ* and *Tortricidæ* which Dr. C. H. Fernald has been conducting have been nearly brought to a conclusion, and the results in part already privately published.² The scope of our research work has been broadened during the year by the addition of two new lines of work, *i.e.*, an investigation of the solubility effect of ammonium sulfate on the soil of field A; and color vision in bees. The progress made in most of these lines of investigation has been satisfactory, but there has been some interruption on account of moving the entomological work into the new building, and on account of ill health of members of our staff, apparently due to overwork. In both departments in which such interruption has occurred changes (already referred to) have been made, including the provision of an additional assistant in each, which, it is believed, will make it possible to push the work of investigation more rapidly.

In the later pages of this report will be found a number of valuable technical papers based upon some of the investigations in progress. The more important of these are as follows:—

Studies in Milk Secretion.

The Determination of Arsenic in Insecticides.

The Purification of Insoluble Fatty Acids.

The Soluble Carbohydrates in Asparagus Roots.

Abnormalities of Stump Growth.

Climatic Adaptations of Apple Varieties.

The progress which has been made in our work with asparagus and cranberries, and the greatly increased facilities for

¹ For full list see Part I., twenty-second annual report.

² On the Dates of Jacob Hübner's Sammlung europäischer Schmetterlinge and Some of His Other Works, C. H. Fernald, Ph. D., author and publisher; The Genera of the Tortricidæ and their types, C. H. Fernald, Ph.D., author and publisher.

investigation in the interest of cranberry growers, are made the subjects of special comment which follows.

ASPARAGUS SUBSTATION, CONCORD.

The details of the work in progress in the substation, maintained in the interest of asparagus growers in Concord, have been carefully looked after by Mr. Charles W. Prescott, to whom, as heretofore, we are greatly indebted for his lively interest and efficient supervision. The work has already given results of much interest, and is likely, I believe, to prove of great value. It will be remembered that it follows two rather distinct lines: (1) breeding experiments, with the hope of producing a rust-resistant type of asparagus; (2) fertilizer experiments, designed to throw light upon the special plant food requirements of the crop.

Breeding Experiments.—In the breeding work which is done at Concord the station is fortunate in enjoying the co-operation of the Bureau of Plant Industry of the United States Department of Agriculture. Mr. J. B. Norton of the Bureau has been assigned by Dr. B. T. Galloway to look after the asparagus breeding experiments. It is a pleasure to testify to the enthusiasm and faithful attention of Mr. Norton, who has not only most energetically prosecuted the breeding work, but has proved of much assistance in making observations and records on the fertilizer plots.

A very large number of crosses between selected plants have been made, and among these different crosses a few have resulted in offspring which seem to be almost absolutely immune to rust. These plants will be propagated and seed raised from them as rapidly as possible, with the object of producing stock for trial upon a more extended scale. If, however, the plants produced by some of the crosses continue to show the immunity exhibited by the seedlings, and if they have, as may be anticipated, the capacity to transmit their characteristics, a very gratifying forward step has certainly been made, and we may confidently anticipate complete success in attaining the end in view. At as early a date as possible, seed and young plants will be produced in quantities sufficient for trial by growers in different localities.

Fertilizer Experiments. — It remains true, as was stated to be the case in earlier reports concerning these experiments, that the growth and development of the crops, even upon the no fertilizer plots, owing to the very thorough preparation which the soil received, is still remarkably vigorous. Naturally, therefore, the varying fertilizer treatment does not as yet show the differences which may be confidently looked for. A few points, however, seem to be sufficiently well established to deserve mention.

The field contains 40 plots of one-twentieth acre each. The crop of 1910 was rather seriously injured by frost, but it was nevertheless fairly satisfactory as to quantity and quality. The past season was the fourth since the plants were set. The first cutting was made on April 23, the last on June 29. The total yield of all the plots was 9,020 pounds and 6 ounces.

Attention is called to the following conclusions, based upon results, as of possible interest: —

(1) The use of fertilizer made up of a combination of nitrate of soda, acid phosphate and muriate of potash, in addition to an application of manure at the rate of 10 tons per acre, has not materially increased the crop in whatever quantity applied.

(2) The use of nitrate of soda in addition to manure at the rate above named, in quantities ranging between the rate of from 311 pounds to 622 pounds per acre, has not increased the crop.

(3) The use of nitrate of soda in addition to a fairly liberal application of acid phosphate and muriate of potash has somewhat increased the crop, but a quantity in excess of 311 pounds has not resulted in further increase.

Chemical Work on Asparagus Roots. — It is a part of the plan of the experiments with fertilizers to study the effects of varying treatment upon the composition of the roots. This investigation on the chemical side is being carried on by Prof. F. W. Morse, who will in due time report fully upon the results of the analytical work. It was thought that a study of the reserve material stored in the roots in the autumn might offer results of especial interest and importance, and although the

investigation is not yet completed, this expectation has been largely realized. The special object in view in the first collection of roots made was to study the effect of the varying use of nitrogen in the form of nitrate of soda upon the reserve material in the roots in the autumn. The following points appear to have been well established by the analyses so far made:—

The amount of nitrogen in the roots in the fall: (1) is increased by application of nitrate of soda; (2) is greater where nitrate was used at the rate of 466 pounds per acre than where it was used at the rate of 311 pounds per acre; (3) is not greater where the nitrate of soda was used at the rate of 622 pounds per acre than where it was used at the rate of 466 pounds per acre.

It is believed, although this has not yet been proved, that the crop of the following season must bear a rather close relation to the amount of reserve material in the roots in the fall. If this be so, and if further investigation gives results in agreement with those already obtained, the conclusion that the use of nitrate of soda among our growers is not infrequently in excess of the most profitable quantity would appear to be justified. This conclusion should, however, for the present be regarded as tentative rather than fully established.

CRANBERRY SUBSTATIONS.

During the past year our work in the interest of cranberry growers has been put upon a much more satisfactory basis than heretofore, through a special appropriation by the Legislature to provide for the work. The amount of this appropriation was \$15,000. A bog containing about 12 acres, lying near Spectacle Pond in East Wareham, with a small amount of adjoining upland, two small buildings and a powerful gasoline engine and pump, were purchased for \$12,600. A building to contain screen and storage rooms, living and office rooms for an assistant, and a small laboratory will be erected early this year at a cost of about \$2,000. The balance of the appropriation will be used for the purchase of additional upland to provide readier access to the building above referred to, in the making of needed

improvements in the pumping machinery and in preparations for experiments.

The cranberry bog purchased is planted with Early Black and the Howe varieties. It lies a little above the usual level of the water in Spectacle Pond, the lift required to flood it usually varying between about 3 and 4 feet. The capacity of the power and pumping machinery is such that the bog can be completely flooded in about six hours. The area of Spectacle Pond is nearly 100 acres, and the supply of water is constant and abundant. Being a "great pond" the waters are under State control. Only one other bog, and that a relatively small one, draws water from the pond, so that there must always be water enough for any possible need for all kinds of experimental work. The bog when purchased was in exceptionally perfect condition. It is one which has the reputation of more than average fruitfulness. The crop last year, as was the case with most of the bogs in the cranberry districts of Massachusetts, was moderate, and the net revenue derived from it was small. It is, however, confidently anticipated that the product of the bog will, over a series of years, be sufficient to produce a considerable net income, which will be used in helping to meet the expenses connected with our experimental work. The crop of the past season brought \$1,255 more than the costs of ordinary maintenance, harvesting, packing, etc. The net sum available towards the costs of experimental work, however, was substantially \$100 less than this, that being the amount which we were compelled to pay for taxes, since the bog had not been the property of the Commonwealth on the first of May.

It will be remembered that our cranberry work thus far has followed two principal lines of inquiry relating (1) to the fertilizer requirements of the crop; (2) to insects affecting it.

Fertilizer Experiments. — The fertilizer experiments begun four years ago in Red Brook bog at Waquoit have been continued. The bog, however, gave only a very small crop during the past season, — a result which we believe to have been due in large measure to the effects of frost. The variations in yield caused by uneven amount of frost damage were so great that it

was impossible to draw conclusions as to the specific effects of the different fertilizer combinations. The fertilizer experiments in the Red Brook bog at Waquoit will be continued during next year, but meanwhile similar experiments will be begun in the Spectacle Pond bog. It is believed that it will be best to discontinue the Waquoit experiments after next year, since they lie at such a distance from the station bog in Wareham as to make proper attention to the work somewhat difficult and expensive.

Insect Work. — Dr. Franklin has devoted himself with great enthusiasm and faithfulness to observations and studies on the insects having a relation either injurious or beneficial to the cranberry industry. He has accumulated a large amount of valuable data, but his work is not advanced to the point where publication seems called for.

CONTROL WORK.

Detailed reports concerning the various lines of control work carried on by the station, prepared by the chemists in charge, will be found in the later pages of this report.

Fertilizer Law. — We have found it impossible during the past few years to exercise an efficient control over the trade in fertilizers and to publish the reports without expending an amount exceeding the sum brought in by the analysis or license fees required by our law. The expenditure in 1909 exceeded the amount of the license fees to the amount of nearly \$1,000. To provide for this excess expenditure by the use of other station funds seriously reduces the amount available for experimental work. Accordingly, the amount of analytical work in connection with the fertilizer control during the past year has been somewhat restricted, and the size of the bulletin giving the results has been reduced. These reductions, while for the time being necessary, are undesirable, and for this reason, as well as for other important reasons, it has been decided to ask for a revision of our fertilizer law. The preparation of the new draft has required a great deal of study and many conferences with parties affected by the law. The more important of the

changes which it provides are an increase in the analysis fee per fertilizer element from \$5 to \$8, and bringing the various grades of agricultural lime within its scope. The other changes which have been made have been designed to remedy defects from the standpoint of administration which the execution of the old law had disclosed, and to make it more definite and explicit on a number of rather important points. The fertilizer law at present in force requires us to publish the dealer's cash price and the percentage of difference between this price and the commercial valuation of the fertilizer. It is not proposed to retain this provision in the new law, as it is felt that it is on the whole likely to prove misleading to the farmer, almost inevitably unfair to dealers, and from no point of view apparently serves any important use.

Dairy Law. — Much time has been spent during the past year also in studying and rewriting the so-called dairy law. Besides various perfecting changes, the most important modification is to bring milk inspectors and the Babcock machinery and apparatus which they use within the scope of the law. There would seem to be equal reason that steps should be taken to insure accuracy of work on the results of which, if unfavorable, the milk dealer or farmer may be prosecuted for infringement of one of our State laws, as for bringing those testing milk and cream for determining its value within the scope of the law.

Feed Law. — The increasing number of feedstuffs in our markets, and the increased extent to which materials of complex character are purchased and used by our farmers, have greatly increased the amount of work required to exercise effective control over the trade in feedstuffs, and we find it to be impossible at the present time to properly execute the law and to publish the results of our inspection for the sum of money provided by the State legislative appropriation for the purpose. It will be necessary, therefore, in the near future, to ask for a revision of this law. The amount of the appropriation should be moderately increased to provide for the much greater amount of work now required than was necessary when the amount of

the appropriation was fixed some eight years ago. In the case of this law, also, practical experience in its execution has made it apparent that some perfecting amendments are necessary in order that it may operate smoothly and effectively.

INSPECTION OF APIARIES.

The great desirability of the passage of a law providing for the inspection of apiaries, with a view to the eradication and control of contagious diseases of bees, was set forth at some length in my last annual report. It seems proper, therefore, in this report to refer to the fact that the Legislature of 1910 passed such an act. The execution of the law, however, was placed with the secretary of the State Board of Agriculture, but the experiment station and college are working in harmony with the secretary. He has named as inspector of apiaries the apiarist of the college and station, Dr. Burton N. Gates, whose appointment has already been referred to.

BUILDINGS.

The new building for the departments of entomology and zoölogy has been completed during the year and has been occupied since September. It is a commodious, fireproof structure, costing \$80,000, and paid for by special appropriation. It provides ample accommodations for the experimental work in entomology. The hothouse, a comparatively new and modern building used in connection with the old insectary for experimental work, has been moved on to new foundations and is connected with the new building.

The necessity for increased accommodations for the research chemical work of the station was pointed out in my last annual report, in which it was stated that plans for enlargement and modification of the old building for the purpose of securing the increased accommodations needed were under consideration. Mature study of the problem as to the best means of providing the needed room, in connection with more exact estimates of the cost of so enlarging and modifying our old laboratory as to meet the requirements, has led to the conclusion that it is unwise to make the relatively large expenditure required for such

enlargement and modification. It seems clear that the old building, however enlarged and improved, must still fail to be entirely adequate or satisfactory, and that therefore it is wiser at this time to make only the few absolutely necessary changes, involving relatively little expenditure, leaving full provision for our needs until such time as the State shall grant the money needed for a new building, which the growth of our work will render imperative in the very near future.

WM. P. BROOKS,

Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

OF FRED C. KENNEY, TREASURER OF THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

For the Year ending June 30, 1910.

The United States Appropriations, 1909-10.

	Hatch Fund.	Adams Fund.
<i>Dr.</i>		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1910, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund), . . .	\$15,000 00	\$13,000 00
<i>Cr.</i>		
By salaries,	\$13,184 81	\$9,918 15
labor,	264 74	817 05
publications,	49 75	—
postage and stationery,	95 12	19 00
freight and express,	—	13 35
heat, light, water and power,	7 43	149 47
chemical supplies,	—	114 41
seeds, plants and sundry supplies,	250 19	496 08
fertilizers,	348 61	95 01
feeding stuffs,	406 48	—
library,	47 44	6 45
tools, implements and machinery,	—	—
furniture and fixtures,	117 00	328 50
scientific apparatus,	123 75	892 02
live stock,	48 00	—
traveling expenses,	56 68	105 51
contingent expenses,	—	—
building and land,	—	45 00
Total,	\$15,000 00	\$13,000 00

State Appropriation, 1909-10.

To balance on hand July 1, 1909,	\$5,538 50
Cash received from State Treasurer,	13,500 00
from fertilizer fees,	5,970 00
from individuals (cranberry con- tribution),	544 17
from farm products,	3,208 73
from miscellaneous sources,	6,387 84
	<hr/>
	\$35,149 24
Cash paid for salaries,	\$8,434 28
for labor,	9,447 30
for publications,	2,313 60
for postage and stationery,	928 20
for freight and express,	381 42
for heat, light, water and supplies,	341 94
for chemical supplies,	542 26
for seeds, plants and sundry supplies,	2,348 15
for fertilizers,	532 83
for feeding stuffs,	1,468 03
for library,	188 46
for tools, implements and machinery,	26 70
for furniture and fixtures,	240 95
for scientific apparatus,	1,018 52
for live stock,	80 38
for traveling expenses,	2,299 51
for buildings and land,	358 33
Balance,	4,198 48
	<hr/>
	\$35,149 24

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS.

The work in the department of agriculture during the past year has been of about the usual scope and extent. The problems which are being investigated are for the most part related to questions connected with the maintenance of fertility. Various questions connected with the selection, adaptation and methods of application of manures and fertilizers are being investigated. Most of our experiments have continued for a considerable number of years. Some indication is afforded of the amount of work in progress by the following statements. The number of field plots on the station grounds used in experiments the past year was 356. Our vegetation experiments have involved the use of 352 pots; while as a check upon the work in the open field, and as a method of throwing light upon a few special problems, 167 closed plots have been used.

No attempt will be made in this report to discuss the work in detail. Attention is called, however, to a few of the more striking results.

I. COMPARISONS OF DIFFERENT MATERIALS AS A SOURCE OF NITROGEN.

These experiments, which are carried on in Field A, were begun in 1890. The materials under comparison as sources of nitrogen are manure, one plot; nitrate of soda, two plots; dried blood, two plots; and sulfate of ammonia, three plots. Nitrate of soda and dried blood are used on one plot with muriate of potash; on the other with sulfate. The sulfate of ammonia is used on two plots in connection with muriate and on one in connection with sulfate of potash.

The different materials furnishing either nitrogen or potash are used on the several plots in such amounts as to furnish, respectively, equal quantities per plot of nitrogen and of potash; two of the three no-nitrogen plots which serve as checks receive potash in the form of muriate, the other in the form of sulfate, and all the plots in the field receive an equal liberal application of dissolved bone black as a source of phosphoric acid.

The crops grown in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas, corn and clover for the last three years. The clover crop of the past year, as was true of the two preceding years, was considerably mixed with grass. The seed was sown early in August, 1909, and just previous to the sowing of the seed one-half of each of the plots in the field received a dressing of lime, at the rate of a ton and one-half to the acre. It was thought that such an application of lime would increase the efficiency of the sulfate of ammonia as a source of nitrogen, and to some extent this expectation appears to have been realized. The differences, however, between the limed and unlimed halves of the plots were relatively small, and the yields on the two halves were not separately determined.

The best crop of the past year was produced where nitrate of soda was used as a source of nitrogen; but the yields on dried blood and on sulfate of ammonia used in connection with sulfate of potash were not much inferior. On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen fertilizers and the no-nitrogen plots as measured by total yield during the past season was as follows:—

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	93.73
Sulfate of ammonia,	95.53
Barnyard manure,	94.75
No nitrogen,	91.79

The relative standing of the different materials as indicated by total yield for the twenty-one years during which the experiment has continued is as follows:—

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.07
Dried blood,	92.38
Sulfate of ammonia,	86.87
No nitrogen,	71.96

On the basis of increase in crop as compared with the no-nitrogen plots, the average of the twenty-one years shows the following relative standing:—

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	78.85
Dried blood,	72.82
Sulfate of ammonia,	53.17

Nitrate of soda has given a much larger increase in crop than any of the other materials, and since the pound cost of the nitrogen of nitrate of soda is usually less than the pound cost in any other chemical fertilizer, the superior economy of its use is apparent.

II. MURIATE COMPARED WITH SULFATE OF POTASH.

Our long-continued experiments comparing muriate with high-grade sulfate as a source of potash have continued on Field B. It will be remembered that the two potash salts are used in such quantities as to furnish equal actual potash per acre. These experiments were begun in 1892. Five pairs of plots are under comparison. From 1892 to 1899 the potash salts were used in quantities (varying in different years, but always in equal amounts on the two members of pairs of plots) ranging from 350 to 400 pounds per acre. Since 1900 the quantity used has been uniform on all plots, and at the rate of 250 pounds per acre annually. Fine ground bone has been annually applied to each plot throughout the entire period of the experiment, and the rate of application is 600 pounds per acre. The season of 1910 is the nineteenth year of these experiments. The crops during that year were potatoes on one pair of plots, oats on one pair, and asparagus, rhubarb and blackberries. The rates of yield per acre on the different potash salts are shown in the following tables:—

	RATE PER ACRE (POUNDS).		
	Asparagus.	Rhubarb.	Blackberries.
Muriate of potash,	5,604	24,587	2,661
Sulfate of potash,	4,143	25,856	2,821

	RATE PER ACRE.		
	POTATOES (BUSHELS).		Oat Hay (Pounds).
	Merchantable.	Small.	
Muriate of potash,	204.6	11.15	3,716
Sulfate of potash,	255.4	13.02	3,345

These figures call for but little comment, as they are in general in full agreement with results previously obtained. The asparagus gives a larger yield on the muriate of potash, which indicates the correctness of the ordinary practice of asparagus growers, who usually employ the muriate as a source of potash.

The rhubarb gives a slightly larger yield on the sulfate, and it was noticed during this year, as it has usually been in previous years, that the proportion of leaf to stalk is greater on the sulfate than on the muriate, the figures for this year on total weight of leaf being at the following rates per acre: —

	Pounds.
Muriate,	18,410
Sulfate,	20,560

No explanation can at present be offered for this difference.

The blackberries gave a larger yield on the sulfate, but the difference is not great. This, however, is in accordance with our observations in the case of most fruits, strawberries alone excepted, that sulfate of potash gives a better yield than muriate.

The difference in yield in potatoes on the two plots amounts to rather over 50 bushels. Such differences have been common in our experiments in earlier years, not only in this field, but in others as well. The difference in character of foliage of the potatoes on the two plots was strikingly evident from a period very early in their appearance above ground. The foliage of

the potatoes on the muriate of potash plots was lighter in color, it may be described as a pea green, while that on the sulfate of potash plot was of a much darker shade. An attempt has been made to demonstrate whether there is a difference in the amount of chlorophyl developed in the foliage produced, respectively, by the different potash salts, but the efforts so far made have not demonstrated such a difference. It is perfectly clear, however, that the muriate of potash as compared with sulfate is distinctly unfavorable to the production of starch in the tubers, the percentage of this constituent being almost invariably considerably higher than in the potatoes produced on the muriate.

The yield of oat hay on the muriate is considerably heavier than on the sulfate, and this result seems to be somewhat in harmony with results which we have previously obtained with corn, in the case of which grain the yield of stover on the muriate appears to be usually heavier than on the sulfate under otherwise similar conditions.

III. NITROGEN FERTILIZERS AND POTASH SALTS FOR GARDEN CROPS.

Three different nitrogen fertilizers, sulfate of ammonia, nitrate of soda and dried blood, and two potash salts, muriate and high-grade sulfate, each salt being used with each of the nitrogen fertilizers, are under comparison on Field C. In connection with the fertilizers named dissolved bone black was used in liberal amounts, which are the same on all plots. The comparison of these different fertilizers in this field was begun in 1891, but up to 1898 they were used alone. Since that time all plots have received annually a dressing of stable manure, at the rate of 30 tons per acre. The nitrogen fertilizers are used in such quantities as to furnish nitrogen at the rate of 60 pounds per acre, the potash salts in such quantities as to furnish 120 pounds of actual potash per acre, and the dissolved bone black was applied at the rate of 320 pounds per acre. The crops of the past year were asparagus, strawberries and onions.

Yields per Acre.

Plot.	FERTILIZERS.	Asparagus (Pounds).	Strawberries (Pounds).	ONIONS (BUSHELS).	
				Large.	Picklers.
0,	No fertilizer, . . .	3,378	7,012	304.4	53.5
1, {	Muriate of potash, . . .	3,984	7,661	173.1	39.3
	Sulfate of ammonia, . . .				
2, {	Muriate of potash, . . .	5,057	5,088	258.3	69.0
	Nitrate of soda, . . .				
3, {	Muriate of potash, . . .	5,052	6,697	259.2	40.2
	Dried blood, . . .				
4, {	Sulfate of potash, . . .	3,764	6,087	150.0	34.6
	Sulfate of ammonia, . . .				
5, {	Sulfate of potash, . . .	5,235	5,204	300.6	56.4
	Nitrate of soda, . . .				
6, {	Sulfate of potash, . . .	5,417	7,488	253.4	37.9
	Dried blood, . . .				

Attention is called in commenting upon these results to the fact that manure is used on Plot O at the same rate as on the other plots.

Asparagus. — Asparagus has long been recognized as a rank feeding crop, requiring liberal application of manure and fertilizers. It will be noticed that this is the only one of the three crops which appears to have been materially benefited by the use of the fertilizers. The crop on Plot O, on manure alone, is materially smaller than on either of the other two plots. Particular attention is called to the highly unfavorable effect of the combinations containing the sulfate of ammonia. The yields where this fertilizer was used are much below those produced where the other nitrogen fertilizers are employed, and not materially greater than where no fertilizer is used.

Strawberries. — It will be noted that in marked contrast with the results obtained with asparagus the yields of strawberries are highest on plots where sulfate of ammonia is used. A similar result has been obtained in earlier years. The highest yield of all has been produced where muriate of potash is used in connection with sulfate of ammonia, a combination which for

most crops has always seemed to be peculiarly unfavorable. Whether a similar result would be obtained in soils less highly enriched is at present a matter of uncertainty, but I desire to point out that in my judgment, based not only upon the yields of strawberries, which are not as large on the best of our plots as are obtained in good practice, but also upon the growth and development of the vines, flowers and fruit, the rate of use of manure and fertilizer in Field C is much too high for the best results. The vines have been over-rank, the fruit has set rather imperfectly and ripened poorly.

Onions. — Comparison of the yields on the different plots shows that none of the fertilizers used in connection with manure have apparently been beneficial. The combination containing sulfate of potash and nitrate of soda has done best; but the most significant point in connection with these results is the distinctly unfavorable effect of the combinations which contain sulfate of ammonia. The yield where this fertilizer is used is much below that on the other plots. The onions where this fertilizer is applied appear to stand practically still for a number of weeks after germination. They become distinctly unhealthy and many die. By midsummer the unfavorable influence disappears, the remaining plants take on a rank growth, the tops are heavy, the necks of the bulbs are thick, and comparatively few well-ripened bulbs are produced. It is probable that a heavy application of lime in connection with the sulfate of ammonia will in large measure, perhaps altogether, correct the faulty conditions which appear to be due to the use of this fertilizer.

IV. RELATIVE VALUE OF DIFFERENT POTASH SALTS.

The experiments comparing different potash salts were begun in 1898. The following materials are under comparison: kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and feldspar. There are 40 plots in all. Five have received no potash since the experiments began. Each potash salt is used on five different plots; in other words, there are five series of plots. The crop during the past year was hay (mixed timothy, redtop and clovers). The average yields on each treatment are shown in the following table: —

Average Yield per Acre (Pounds).

	Hay.	Rowen.
No potash, plots 1, 9, 17, 25, 33,	6,240	698
Kainit, plots 2, 10, 18, 26, 34,	6,656	966
High-grade sulfate, plots 3, 11, 19, 27, 35,	6,416	1,866
Low-grade sulfate, plots 4, 12, 20, 28, 36,	6,864	2,058
Muriate, plots 5, 13, 21, 29, 37,	6,976	1,752
Nitrate, plots 6, 14, 22, 30, 38,	7,784	1,916
Carbonate, plots 7, 15, 23, 31, 39,	6,280	1,984
Fine-ground feldspar, plots 8, 16, 24, 32, 40,	6,824	1,256
Average of all potash plots,	6,828	1,685

The various potash salts used are employed in such quantities as to furnish substantially equal actual potash to each plot. In the case of the feldspar, which is very fine ground, the quantity employed on Plot 8 furnishes the same amount of potash as that supplied by the different potash salts. Plot 16 receives the same amount as Plot 8, Plot 24 receives twice as much, Plot 32 three times as much, and Plot 40 four times as much. Particular attention is called to the fact that up to and including 1908 the plots now receiving feldspar had been annually receiving a potash salt which had given results indicating a high degree of availability. It is believed that the crops on these plots are still deriving considerable benefit from the residual potash applied in the earlier years of the experiment.

The following points seem especially worthy of notice:—

(1) The average yield of hay on all the potash plots exceeds the average yield on the no-potash plots by only 600 pounds. The average yield of rowen on the potash plots exceeds the yield on the no-potash plots by about 1,000 pounds. These figures indicate that the grasses, timothy and redtop, which make up the bulk of the first crop, are not dependent in very high degree upon an application of potash, and the much larger increase in the yield of rowen on the potash plots is clearly to be attributed to the fact that clovers make up the greater part of the rowen.

(2) The kainit, while favorable to the grasses, such as timothy and redtop, and therefore giving a first crop nearly equal

to the average for the potash salts, is distinctly inferior to any of the materials supplying potash in its effects upon the rowen. This is undoubtedly due to the large proportion of chlorides which kainit contains.

(3) It will be noticed that the yield of rowen on muriate of potash is considerably less than on either of the sulfates, the nitrate or the carbonate. We have noticed in our experiments that the muriate almost always proves distinctly less favorable to clovers than the sulfates. On the other hand, this salt appears to be highly favorable to the timothy and redtop, as is indicated by the relatively high yield of hay.

(4) The yield of rowen is highest on the low-grade sulfate of potash, and there is a noticeable difference in its favor in the yield of hay also. It is possible that the magnesium contained in this salt is proving of value for the hay crops.

The most marked result of the substitution during the past few years of feldspar for the silicate of potash used in the earlier years of the experiment on Plots 8, 16, 24, 32 and 40 has been the rapid disappearance of clover from these plots. This fact indicates that the claim of the manufacturers that the potash of the feldspar has been rendered available by the treatment to which it has been subjected is not justified by the facts. After two years the clover has disappeared from these plots almost as completely as from the plots to which no potash has been applied throughout the entire period of the experiment.

V. COMPARISON OF DIFFERENT PHOSPHATES.

Ten of the leading materials which may be used as a source of phosphoric acid have been under comparison in one of our fields since 1897. The different materials are applied to the separate plots in such quantities as to furnish equal amounts of actual phosphoric acid to each. There are three check plots to which no phosphate whatever has been applied during the entire period of the experiment. All the plots receive annually equal and liberal quantities of materials supplying nitrogen and potash in highly available forms. The field has been used for a large variety of crops, the succession having been as follows: corn, cabbages, corn, oats and Hungarian grass (followed by

rye plowed under), onions, onions, cabbages, corn, mixed grass and clover three years, cabbages and soy beans. The crop this year was potatoes. The results are shown in the following table: —

Comparison of Phosphates.

Plot.	FERTILIZER.	Yield Merchant- able Potatoes per Plot (Pounds).	YIELD PER PLOT (POUNDS).		Yield Merchant- able Potatoes per Acre (Bushels).	Loss or Gain per Acre (Bushels).
			Small.	Rotten.		
1,	No phosphate, . . .	2,148	94	6	286.4	-
2,	Arkansas rock phosphate, .	2,170	89	12	289.3	+40.9
3,	South Carolina rock, . .	1,986	53	23½	264.8	+16.4
4,	Florida soft rock, . .	1,761	107	24	234.8	-13.6
5,	Phosphatic slag, . . .	1,841	76	18	245.5	-2.9
6,	Tennessee phosphate, .	1,773	109	34	236.4	-12.0
7,	No phosphate, . . .	1,831	53	36½	244.1	-
8,	Dissolved bone black, .	1,859	90	12½	247.9	-0.5
9,	Raw bone meal, . . .	1,941	140	12	258.8	+10.4
10,	Dissolved bone meal, . .	1,982	121	15	264.3	+15.9
11,	Steamed bone meal, . .	1,964	101	11½	261.9	+13.5
12,	Acid phosphate, . . .	1,929	120	9½	257.2	+8.8
13,	No phosphate, . . .	1,610	107	11½	214.7	-

The yield, as will be seen, was good on all plots. The average on the three check plots is 244.8 bushels of merchantable potatoes per acre. It will be noticed that the only one of the phosphates used which has given any very considerable increase in merchantable potatoes is the Arkansas rock phosphate, but I am convinced that the superiority of this phosphate is more apparent than real. The field declines somewhat in fertility from Plot 1 to Plot 13. It will be noticed that Plot 1 without phosphate gives a yield of merchantable tubers larger than any of the phosphate plots, with the exception of two, and that the crop on two is practically the same in amount as on one. The superior yield on these two plots is in my judgment merely a consequence of the fact that the soil texture in that part of the field is more favorable to the crop. The conclusions to which I would call particular attention may be stated as follows: —

(1) The potato would appear to be a crop relatively inde-

pendent of a supply of immediately available phosphoric acid. The result with potatoes offers a striking contrast to the result obtained in 1908 with cabbages, with which the crop on some of the best phosphate plots was more than six times greater than that produced on the no-phosphate plots. .

(2) Although the phosphate used affected the total yield but little, it was noticed that during the first few weeks of their growth the vines on the plots to which the more available phosphates had been applied (phosphatic slag, dissolved bone black, dissolved bone meal and acid phosphate), made a much more rapid growth than on the other plots. The use of a little phosphoric acid, therefore, in highly available form, seems likely to prove a distinct advantage by pushing the crop more rapidly forward, so that it may better resist attacks of insects or unfavorable conditions which may occur later. It seems likely, further, that where the crop is cultivated for an early market the use of moderate amounts of highly available phosphoric acid may prove beneficial.

(3) The potatoes produced on the plot to which phosphatic slag has been annually applied for so many years were very scabby, although the seed planted was treated with formalin, as was that planted on the other plots also. So serious was this trouble that the market value of the crop was very greatly reduced, and the conclusion appears justified that a free use of phosphatic slag in the same season that land is to be planted with potatoes must in general prove highly undesirable. Slag meal is a strongly alkaline fertilizer, and this is undoubtedly the cause of the very scabby crop produced, since the scab fungus is known to be most troublesome in soils which are alkaline.

VI. MANURE ALONE COMPARED WITH MANURE AND SULFATE OF POTASH.

This experiment, which occupies what is known as the south corn acre, has been in progress since 1890. The field is divided into four plots of one-fourth acre each. Good barnyard manure from milch cows, at the rate of 6 cords per acre, has been applied annually, with the exception of those years when it was

feared so doing would cause the newly seeded grass and clover to lodge, to two of these plots. Manure at the rate of 3 cords per acre, together with high-grade sulfate of potash at the rate of 160 pounds per acre, was applied to the other two plots from 1890 to 1895. Since the latter date the manure has been applied to these plots at the rate of 4 cords per acre in connection with 160 pounds of high-grade sulfate of potash, and whenever, for the reasons above stated, the application of manure has been omitted from the other two plots, both the manure and the potash have been withheld from these plots. The plan of cropping this field for the last twelve years has been corn and hay in rotation in periods of two years for each. During the past season the crop on this field has been hay, and the average yields per acre have been as follows:—

	Pounds.
Manure alone:—	
Hay,	4,480
Rowen,	1,050
Manure and potash:—	
Hay,	4,400.
Rowen,	940

The rowen crop of the past season was very small, owing to the marked deficiency in rainfall. The corn crops raised in this field throughout the entire period of the experiment have been very nearly equal under the differing manurial treatments. The hay crops have usually been somewhat larger with the manure alone. The difference during the past season is considerably less than the average.

VII. AVERAGE CORN FERTILIZER COMPARED WITH FERTILIZER RICHER IN POTASH.

These experiments occupy what is known as the north corn acre. They have been in progress since 1891. This field, like the south corn acre, is divided into four plots of one-fourth acre each. Two of the plots receive a mixture furnishing nitrogen, phosphoric acid and potash in the same proportions in which they are contained in the average corn fertilizers offered in our markets. The other two plots annually receive an ap-

plication of a home-made mixture, containing much less phosphoric acid and more potash than is applied to the other plots. For the past fifteen years corn and hay, two years each, have regularly alternated. The crop of the past season was hay. Owing to the marked deficiency in rainfall already referred to the rowen crop was almost an absolute failure. The average yields were at the following rates per acre:—

	Pounds.
On the fertilizer rich in phosphoric acid and low in potash:—	
Hay,	3,260
Rowen,	330
On the fertilizer low in phosphoric acid and rich in potash:—	
Hay,	3,500
Rowen,	240

The results of the past season are similar to those which we have usually obtained, except that owing to the protracted drought the production of rowen on the plots receiving the larger proportion of potash is much lower than usual. In an average season the yield of rowen on these plots has invariably been greater than on the others.

VIII. SOUTH ACRE SOIL TEST.

The crop raised in the south acre soil test which has continued in this field since 1889 was corn. The succession of crops grown on this field from the beginning of the experiment up to the present time has been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard (plowed in), corn, corn, grass and clover, grass and clover, corn, corn, corn, grass and clover, grass and clover, corn, oats and clover, buckwheat plowed under, corn. During the continuance of the experiment the field has been limed at the rate of a ton to the acre three times. The results of the past season with corn were entirely similar to those which have usually been obtained with that crop. Potash is still the dominant element. The average yield on the no-fertilizer plots, three in number, was at the rate of 4.05 bushels per acre. Muriate of potash alone increases the crop to nearly 23 bushels. Nitrate of soda alone gives a crop of 9 bushels. Dissolved bone black alone gives a yield at the rate of 4.21

bushels. The average increases due to the application of the different fertilizers (used in each case on four plots) were as follows: —

	Bushels per Acre.
Nitrate of soda,	3.2
Bone black,	6.8
Potash,	28.3

If we represent the average increase in grain due to the nitrate at 100, that due to the bone black is 212, that due to the potash 880.9. Similar figures for the stover are: —

	Pounds per Acre.
Nitrate,	186.2
Bone black,	406.5
Potash,	1,922.7

IX. NORTH ACRE SOIL TEST.

The soil test in this field was begun in 1890, and the crops grown since that year in the order of succession have been as follows: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and turnips, potatoes, onions, onions, onions, potatoes, grass and clover, grass and clover, corn, soy beans, grass and clover, grass and clover, grass and clover. The crop the past year was soy beans, for which the potash appears to be the dominant element. In this field one-half of each of the plots, which are long and narrow, has received three applications of lime, respectively, in 1899, 1904 and 1907. On the limed portion the increases due to the application of single fertilizer materials for the muriate of potash alone was 10.22 bushels per acre; for the nitrate of soda alone, 0.12 bushels; for the dissolved bone black alone, a loss of 4.45 bushels. The muriate of potash in combination with the other fertilizer elements did not give as large an increase in the crop as when used alone. The results will not be discussed in full at this time, but I may add that they are such as to suggest that the soda of the nitrate of soda is to a considerable extent either rendering the natural potash compounds of the soil available, or is itself to some extent taking the place of potash in the economy of the plant.

X. TOP-DRESSING FOR HAY.

The experiments in the production of hay, by using in rotation as top-dressing barnyard manure, wood ashes and a mixture of bone meal and muriate of potash, have been continued during the past year in the nine-acre field where these experiments have been in progress since 1893. The average yield for the entire area this year was at the rate of 5,853 pounds per acre. The yields on the different materials used in top-dressing were at the following rates per acre:—

	Pounds.
Barnyard manure,	5,641
Fine ground bone and muriate of potash,	6,076
Wood ashes,	5,523

The crops this year were lighter than usual, as a consequence, without doubt, of the marked deficiency in rainfall already referred to. The average yields to date under the different systems of top-dressing have been at the following rates per acre:—

	Pounds.
Barnyard manure,	6,343
Wood ashes,	5,789
Fine ground bone and muriate of potash,	6,159

The average yield of the 9 acres from 1893 to 1910 inclusive has been at the rate of 6,134 pounds per acre. The rates of application per acre are:—

1.	Barnyard manure,	8 tons.
2.	Wood ashes,	1 ton.
3.	{ Ground bone,	600 pounds.
	{ Muriate of potash,	200 pounds.

XI. WINTER V. SPRING APPLICATION OF MANURE.

The experiments in progress for the purpose of testing the relative advantages of applying manure in the winter or in the spring were begun in 1899. There are five pairs of plots. In each pair the manure is applied to one plot some time during the winter. At the same time sufficient manure for the other and of the same quality is placed in a large heap, from which it

is spread in the spring. The field in which these experiments are in progress has a decided slope lengthwise of the plots, which lie side by side. The manure which is put on in the winter is applied to the various plots at different times. The crop of the past season was hay, mixed timothy, redtop and clovers. The supply of manure for use in the experiments this year was not as large as usual and Plot 4 was not top-dressed. The results on this plot, therefore, for this season illustrate simply the residual effects of the two systems of applying manure. It must be pointed out, also, that owing to the relatively slow accumulation of manure used in this experiment the quantity available for Plot 3 was not sufficient until the last of March, so that this year the manure was applied both to the north and south half of this plot on the same date, March 31. The results are shown by the following tables.

Yield per Acre (Pounds).

PLOT.	NORTH HALF. WINTER APPLICATION.		SOUTH HALF. SPRING APPLICATION.	
	Hay.	Rowen.	Hay.	Rowen.
1,	6,312	534	6,925	1,009
2,	6,252	1,049	6,826	950
3,	7,004	811	6,905	1,068
4,	5,857	534	6,114	752
5,	8,904	930	8,528	1,563

Relative Yields (Per Cent.).

PLOT.	NORTH HALF. WINTER APPLICATION.		SOUTH HALF. SPRING APPLICATION.	
	Hay.	Rowen.	Hay.	Rowen.
1,	100	100	109.7	188.9
2,	100	100	109.2	90.6
3,	100	100	98.6	131.6
4,	100	100	104.4	141.0
5,	100	100	95.8	168.1

Hay and Rowen (combined). — Average Yields.

PLOT.	NORTH HALF. WINTER APPLICATION.		SOUTH HALF. SPRING APPLICATION.	
	Per Acre (Pounds).	Per Cent.	Per Acre (Pounds).	Per Cent.
1,	6,846	100	7,934	115.9
2,	7,301	100	7,776	106.5
3,	7,815	100	7,973	102.0
4,	6,391	100	6,866	107.4
5,	9,834	100	10,091	102.7

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

This report is intended to give an outline of the work accomplished and in progress in the department of plant and animal chemistry for the year 1910.

1. CORRESPONDENCE.

There have been substantially 5,000 letters sent out during the year ending Dec. 1, 1910, the estimate being made on the basis of stamps used. The correspondence divides itself into (*a*) answering letters of inquiry, (*b*) the execution of the fertilizer, feed and dairy laws, (*c*) the testing of cows, and (*d*) the ordering of supplies.

2. NUMERICAL SUMMARY OF WORK IN THE CHEMICAL LABORATORY.

From Dec. 1, 1909, to Dec. 1, 1910, there have been received and examined 101 samples of water, 459 of milk, 2,799 of cream, 151 of feed stuffs, 223 of fertilizers and fertilizer materials, 44 of soils and 48 miscellaneous. In connection with experiments made by this and other departments of the station, there have been examined 247 samples of milk, 115 of cattle feeds and 300 of agricultural plants. There have also been collected and examined 890 samples of fertilizer, in accordance with the requirements of the fertilizer law, and 1,055 samples of cattle feeds, in accordance with the requirements of the feed law. The total for the year has been 6,432. This summary does not include work done by the research division.

In addition to the above, 10 candidates have been examined

and given certificates to operate Babcock machines, and 4,047 pieces of Babcock glassware have been tested for accuracy of graduation, of which 41, or 1.01 per cent., were inaccurate.

3. LABORATORY WORK OF THE RESEARCH SECTION.

Messrs. Holland and Reed have continued work on the preparation of chemically pure insoluble fatty acids, and on the perfecting of methods for their quantitative determination. Investigations have also been continued relative to the cause of rancidity of fats, and upon the composition and preparation of chemically pure insecticides, particularly Paris green, arsenates of lead and arsenite of lime. Papers entitled "The Purification of Insoluble Fatty Acids" and "The Determination of Arsenic in Insecticides" are presented elsewhere in this report, and likewise in the "Journal of Industrial and Engineering Chemistry."

Mr. Morse has devoted his time to studying the effect of fertility on the chemical composition of asparagus roots, and presents a preliminary paper in this report and in the "Journal of the American Chemical Society" entitled "Soluble Carbohydrates of Asparagus Roots." Chemical analyses showed clearly that there was a marked increase in the total nitrogen in the roots, produced by the addition to the soil of different amounts of nitrate of soda. Low applications of nitrate gave an increase, medium still more, but high applications did not appear to be more effective than medium ones.

The carbohydrates in the reserve material of the roots consisted mainly of a soluble sugar, made up of fructose and glucose, the former decidedly in excess. Nitrogenous fertilizers apparently had no direct effect on the carbohydrates. In general the increase in protein accompanied a lower proportion of total carbohydrates, including fiber. Seventy-six samples of roots were gathered in November to repeat the nitrogen series and to extend the investigations to the effect of phosphorus and potassium.

Mr. Morse has also done some preliminary work in studying the character of the drainage waters from miniature cranberry bogs constructed under the direction of Director Brooks.

At intervals study has also been given to the chemistry of the soils on Field A, in hopes of ascertaining the cause or causes of clover sickness, but no definite results can be reported.

4. RESEARCH WORK IN ANIMAL NUTRITION.

Work is in progress to study the effect of lactic and butyric acids upon the digestibility of food. It has been shown that molasses is responsible for a decided digestion depression upon the foodstuffs with which it is fed. It being recognized that such material in the digestive tract is a large yielder of organic acids, it seemed at least possible that it is these acids which check the further action of the micro-organisms, and prevent their attacking the more difficultly digestible fiber, pentosans and gums.

A paper is presented elsewhere in this report attempting to show the protein requirements of dairy animals. Most dairy animals respond to increased amounts of protein over a protein minimum. By minimum is meant the amount required for maintenance plus that required in the milk. An excess of 25 per cent. over the minimum seems to give very satisfactory results, and is sufficient under most conditions.

Two experiments with dairy cows have been completed to note the comparative effects of corn meal, dried beet pulp and dried molasses beet pulp for milk production. Another experiment with corn meal versus ground oats has also been completed. The results have not been worked out.

The complete records of the station herd have been tabulated from 1896 through 1909, giving such data as food cost of milk production, dry and digestible matter required to produce definite amounts of milk, total solids and fat, relation of grain to roughage, etc. The food cost of 5 per cent. milk for 1909 was 3.3 cents per quart.

Tabulations.

There has been prepared and will be found elsewhere in this report the following tabulations: —

1. Analyses of all cattle feeds made in this laboratory through 1910.

2. Important ash constituents in cattle foods.
3. Composition of dairy products.
4. Digestion coefficients obtained from experiments made in the United States.
5. Composition of fertilizer materials and of natural and waste products.
6. Fertilizer constituents of fruit and garden crops.
7. Relative proportion of phosphoric acid, potash and nitrogen in fruit and garden crops.
8. Composition of some Massachusetts soils.

5. REPORT OF THE FERTILIZER SECTION.

Mr. H. D. Haskins makes the following report:—

The principal work of this section has had to do with the execution of the fertilizer law of the State. Our experience this season indicated a very active demand for both chemicals and factory-mixed commercial fertilizers. There was a larger number of brands licensed than ever before. The inspection did not include the collection of as large a number of samples as during the previous year, although about the same number of brands were analyzed. It has been necessary to curtail somewhat, in order to keep as nearly as possible within the income derived from the fertilizer analysis fees. The expense of the inspection work has increased from year to year, and necessitates a larger income. It has also become evident that the old law requires many changes in order to make it applicable to present conditions. An attempt to improve the law is now under consideration.

Fertilizers licensed.

During the season of 1910 analysis fees have been paid by 83 manufacturers, importers and dealers, including the various branches of the American Agricultural Chemical Company, upon 465 distinct brands of fertilizer, including agricultural chemicals and by-products. Five more certificates of compliance have been issued, including 34 more brands than during 1909. They may be classed as follows:—

Complete fertilizers,	316
Fertilizers furnishing phosphoric acid and potash,	14
Ground bone, tankage and dry ground fish,	53
Chemicals and organic compounds furnishing nitrogen, . . .	82
Total,	465

Fertilizers collected.

With but few exceptions, representative samples of every brand of fertilizer sold in the State have been secured. The collection work was in charge of Mr. James T. Howard, the regular inspector, assisted by Mr. A. B. Harris. As a general rule an effort has been made to collect samples of the same brand in different parts of the State, and to make one analysis of a composite sample made up of equal weights of the several samples. It is believed that this method will prove more satisfactory than when the results are based upon the analysis of a single sample. In all cases at least 10 per cent. of the number of bags found present were sampled; in cases where only a small amount of any particular brand was found in stock a larger percentage of the bags was sampled (often 50 to 100 per cent.), and in no case were less than five bags sampled without the fact being stated on the guarantee slip which is sent to the station laboratory with every brand of fertilizer sampled. One hundred and fourteen towns were visited, and samples of fertilizers were taken from 291 different agents. Eight hundred and ninety samples were drawn, representing 487 distinct brands. Some of the brands represent private formulas which farmers have had manufactured for their own use. The analyses of such brands were published in the bulletin in a table by themselves.

Fertilizers analyzed.

A total of 612 analyses was made in connection with the inspection of 1910. They may be grouped as follows:—

Complete fertilizers,	418
Fertilizers furnishing potash and phosphoric acid, such as ashes, superphosphates and potash,	21
Ground bones, tankage and fish,	71
Nitrogen compounds,	50
Potash compounds,	32
Phosphoric acid compounds,	20
Total,	612

The analyses were made in accordance with methods adopted by the Association of Official Agricultural Chemists. The analysis of a composite sample was made whenever possible, and in instances where such an analysis has shown a brand to be seriously deficient in one or more elements, a new portion was drawn from each original sample collected and a separate analysis made. This was done to determine whether the shortage was confined to one sample or whether it was general in case of that particular brand.

Twelve samples of lava fertilizer, so called, were analyzed. Although these materials have not been offered for sale in Massachusetts, considerable literature concerning them has been circulated, and it was thought best to have representative samples examined and the results published.

Thirty-two more analyses were made than during the previous year.

Trade Values of Fertilizing Ingredients.

The following table of trade values of fertilizer ingredients was used. It was adopted by the experiment stations of New England, New Jersey and New York at a meeting held in March, 1910. For purposes of comparison the 1909 schedule is also given.

	CENTS PER POUND.	
	1909.	1910.
Nitrogen: —		
In ammonia salts,	17	16
In nitrates,	16½	16
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	19	20
Organic nitrogen in fine ¹ bone and tankage,	19	20
Organic nitrogen in coarse ¹ bone and tankage,	14	15
Phosphoric acid: —		
Soluble in water,	4	4½
Soluble in neutral citrate of ammonia solution (reverted phosphoric acid), ²	3½	4
In fine ¹ bone and tankage,	3½	4
In coarse ¹ bone and tankage,	3	3½
In cottonseed meal, linseed meal, castor pomace and ashes,	3	3½
Insoluble in neutral citrate of ammonia solution (in mixed fertilizers),	2	2
Potash: —		
As sulfate, free from chlorides,	5	5
As muriate (chlorides),	4¼	4¼
As carbonate,	8	8

¹ Fine and medium bone and tankage are separated by a sieve having circular openings one-fiftieth of an inch in diameter. Valuations of these materials are based upon degree of fineness as well as upon composition.

² Dissolved by a neutral solution of ammonium citrate; specific gravity 1.09 in accordance with method adopted by the Association of Official Agricultural Chemists.

These trade values will be found to correspond fairly with the average wholesale quotations of chemicals and raw materials as found in trade publications for the six months preceding March 1, plus about 20 per cent. They represent the average pound cost for cash at retail of the various ingredients as furnished by standard unmixed chemicals and raw materials in large markets in New England and New York for the six months preceding March 1, 1910. The cost of the mineral forms of nitrogen (nitrate of soda and sulfate of ammonia) has been somewhat lower than for the previous year, which has led to a more general use of these forms of nitrogen. Nitrogen from organic sources has been a cent higher than for the season of 1909. The cost of phosphoric acid was one-half cent higher than for the previous season. There was no material change in the cost of the various forms of potash.

Summary of Analyses as compared with Guarantees of Licensed Complete Fertilizers.

MANUFACTURERS.	Number of Brands Analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
W. H. Abbott,	3	1	3	1	1	-
American Agricultural Chemical Company, . .	78	55	75	19	3	-
Armour Fertilizer Works,	11	11	11	-	-	-
Baltimore Pulverizing Company,	4	-	2	4	-	-
Beach Soap Company,	5	3	5	2	-	-
Berkshire Fertilizer Company,	8	6	8	2	-	-
Bonora Chemical Company,	1	-	1	1	-	-
Bowker Fertilizer Company,	30	21	27	7	2	-
Joseph Breck & Sons Corporation,	3	1	3	2	-	-
Buffalo Fertilizer Company,	8	1	6	6	1	-
Coe-Mortimer Company,	13	6	10	3	3	1
Eastern Chemical Company,	1	1	1	-	-	-
Essex Fertilizer Company,	12	4	10	5	3	-
R. & J. Farquhar & Co.,	3	1	3	2	-	-
The Green Mountain Plant Food Company, . .	1	1	1	-	-	-

Summary of Analyses as compared with Guarantees of Licensed Complete Fertilizers — Con.

MANUFACTURERS.	Number of Brands Analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
C. W. Hastings,	1	-	1	1	-	-
Lister's Agricultural Chemical Works,	6	3	6	3	-	-
James E. McGovern,	1	-	1	1	-	-
Mapes' Formula and Peruvian Guano Company,	17	6	17	9	2	-
National Fertilizer Company,	14	8	12	3	3	-
New England Fertilizer Company,	6	3	5	2	-	1
Olds & Whipple,	6	4	6	1	1	-
Parmenter & Polsey Fertilizer Company,	8	1	7	4	3	-
R. T. Prentiss,	4	-	1	2	1	1
Pulverized Manure Company,	2	1	2	-	1	-
W. W. Rawson & Co.,	1	1	1	-	-	-
Rogers Manufacturing Company,	9	3	9	5	1	-
Rogers & Hubbard Company,	8	6	8	2	-	-
Ross Bros. Company,	3	2	3	1	-	-
N. Roy & Son,	1	1	1	-	-	-
Sanderson Fertilizer and Chemical Company,	6	5	6	-	1	-
M. L. Shoemaker & Co., Ltd.,	1	1	1	-	-	-
Swifts' Lowell Fertilizer Company,	17	4	15	9	2	2
W. G. Todd,	1	1	1	-	-	-
Whitman & Pratt Rendering Company,	5	-	5	4	1	-
Wilcox Fertilizer Works,	6	5	6	1	-	-
A. H. Wood & Co.,	3	-	3	2	1	-

The above table shows that 306 distinct brands of licensed complete fertilizers have been collected and analyzed.

That 140 brands (45.75 per cent. of the whole number analyzed) fell below the manufacturer's guarantee in one or more elements.

That 104 brands were deficient in one element.

That 30 brands were deficient in two elements.

That 6 brands were deficient in all three elements.

That 24 out of the 306 brands (7.85 per cent. of the whole number) showed a commercial shortage; that is, they did not show the amount and value of the plant food as expressed by the lower guarantee, although the values of any overruns were used to offset shortages.

The deficiencies were divided as follows:—

60 brands were found deficient in nitrogen.

80 brands were found deficient in available phosphoric acid.

71 brands were found deficient in potash.

When the data furnished by the above summary are compared with those of previous years, it is clear that greater care has been exercised on the part of the manufacturers, the guarantees being more generally maintained.

More brands were deficient in potash than during the previous year, a fact which may be due to temporary shortage in the supply of German potash salts in this country and correspondingly higher prices. These conditions were due to German legislation, which prevented the carrying out of contracts with German mine owners held by American fertilizer manufacturers except on payment of heavy production taxes.

Commercial Shortages.

The brands having a commercial shortage were much fewer in number than for 1909, and the amount or value of the shortages was much less, as may be seen from the following table:—

Commercial Shortages in Mixed Complete Fertilizers for 1910, as Compared with the Previous Year.

COMMERCIAL SHORTAGES.	NUMBER OF BRANDS.	
	1910.	1909.
Over \$4 per ton,	None	1
Between \$3 and \$4 per ton,	None	2
Between \$2 and \$3 per ton,	None	5
Between \$1 and \$2 per ton,	6	14
Under \$1 but not less than 25 cents per ton,	18	35

There were a few brands showing rather serious deficiencies in some element of plant food, but which did not suffer a commercial shortage on account of an overrun of some other ingredient. Such brands, of course, may be seriously out of balance, and while not excusable, the manufacturer evidently had no intention to defraud.

Quality of Plant Food.

As a general rule the potash and phosphoric acid were furnished in the forms guaranteed.

It is hoped that methods of analysis may soon be perfected so that it will be possible to indicate the relative availability of the organic nitrogen in mixed fertilizers. The importance of this may, in a measure, be realized when it is remembered that nearly 45 per cent. of the nitrogen used in the complete fertilizers this year was derived from organic sources.

Grades of Fertilizer.

The following table shows the average comparative commercial values, the retail cash prices and the percentages of difference of the licensed complete fertilizers analyzed in Massachusetts during the season of 1909 and 1910, grouped according to commercial valuation. Those having a valuation of \$18 or less per ton are called low grade; those having a valuation of between \$18 and \$24 are called medium grade; and those having a valuation of over \$24 are called high grade.

	HIGH GRADE.		MEDIUM GRADE.		LOW GRADE.	
	1909.	1910.	1909.	1910.	1909.	1910.
Average ton valuation, . . .	\$27 63	\$28 81	\$20 69	\$21 04	\$15 32	\$15 61
Average cash price, . . .	\$39 05	\$38 40	\$33 85	\$33 51	\$29 51	\$27 80
Average money difference, . .	\$11 42	\$9 59	\$13 16	\$12 47	\$14 19	\$12 19
Percentage difference, . . .	41.33	33.28	63.61	59.26	92.62	78.03

The percentage of difference column becomes a convenient method of comparing the commercial worth of fertilizers of the same grade and cost, and usually indicates fairly the most eco-

nomical fertilizer to purchase. It should never be interpreted as representing only the profit which the manufacturer makes on his fertilizer. It must include not only the profit, but all other expenses connected with the manufacture and delivery of the goods, such as grinding, mixing, bagging, transportation, agents' profits, long credits, interest and depreciation of factory plants.

Composition according to Grade.—The following table shows the average composition of the complete commercial fertilizers, according to grade, as sold in the Massachusetts markets during 1910:—

GRADE.	Number of Brands.	Per Cent. of Whole Number.	Per Cent. of Nitrogen.	PER CENT. OF PHOSPHORIC ACID.			Per Cent. of Potash.	Pounds of Available Plant Food in 100 Pounds of Fertilizer.
				Soluble.	Reverted.	Available.		
High,	151	44.67	4.22	3.88	3.26	7.14	7.63	18.99
Medium,	120	35.50	2.65	4.86	2.81	7.67	5.06	15.38
Low,	67	19.83	1.77	4.55	2.46	7.01	3.06	11.84

A study of the above tables shows:—

1. That the percentage difference or percentage excess of the selling price over the valuation in the low-grade fertilizer is over twice what it is in the high-grade goods.

2. That with a 38 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes over 84 per cent. increase in commercial value.

3. The average high-grade fertilizers, with a 14.6 per cent. advance in price over the medium-grade goods, furnishes about 23 per cent. more plant food and about 37 per cent. increase in commercial value.

4. That with a 38 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes more than 78 per cent. increase in available plant food.

5. The medium-grade goods cost about 20 per cent. more

than the low-grade goods and furnish over 34 per cent. greater commercial value.

6. That the per cent. of nitrogen and potash is very much higher in the high-grade goods than in the low or medium grade.

7. A ton of the average high-grade fertilizer furnishes about 49 pounds more nitrogen, $2\frac{1}{2}$ pounds more available phosphoric acid and 91 pounds more actual potash than does a ton of the low-grade goods.

8. A ton of the average high-grade fertilizer furnishes about 31 pounds more nitrogen and about 51 pounds more potash than does a ton of the medium-grade goods.

Table showing the Comparative Pound Cost, in Cents, of Nitrogen, Potash and Phosphoric Acid in its Various Forms in the Three Grades of Fertilizer.

ELEMENT.	Low-grade Fertilizer.	Medium-grade Fertilizer.	High-grade Fertilizer.
Nitrogen,	35.62	31.85	26.66
Potash (as muriate),	7.57	6.77	5.67
Soluble phosphoric acid,	8.01	7.17	6.00
Reverted phosphoric acid,	7.12	6.37	5.33
Insoluble phosphoric acid,	3.56	3.19	2.67

This table emphasizes the marked increase in the cost of plant food wherever the low and medium grade fertilizers are purchased. It shows that nitrogen has cost 8.96 cents, available phosphoric acid about 2 cents and potash 1.9 cents per pound *more* in the average low-grade fertilizer than in the high-grade goods. It shows that nitrogen has cost 5.19 cents, the available phosphoric acid 1.11 cents and the potash 1.10 cents *more* per pound in the average medium-grade goods than in the average high-grade fertilizer. A comparison with the previous year shows that more high-grade brands have been sold this season than for 1909. There is, however, altogether too large a proportion of low and medium grade brands sold at present (55.33 per cent. of the whole). It is evident that too many purchasers select a fertilizer for its low cost, and without much

regard for the plant food which they are getting. The object in buying a fertilizer should be to get the largest amount of plant food in the proper form and proportion for the least money. The high-grade goods approach as near this ideal as is possible in case of factory-mixed fertilizers. It costs just as much to freight, cart and handle the low-grade fertilizers as it does the high grade. Nitrogen and potash in low-grade fertilizers cost from a third to a half more than if obtained from high-grade goods. *The farmer cannot afford to buy low-grade fertilizers.*

Unmixed Fertilizers.

MISCELLANEOUS SUBSTANCES. — *Ground Bone.* — Thirty-nine samples of ground bone have been inspected and analyzed. Nine were found deficient in phosphoric acid and 5 in nitrogen. None of the brands, however, showed a commercial shortage of 50 cents per ton. The average retail cash price for ground bone has been \$31.13 per ton, the average valuation \$29.75, and the percentage difference 4.64.

Ground Tankage. — Twelve samples of tankage have been analyzed. Four were found deficient in nitrogen and 4 in phosphoric acid. The average retail cash price per ton was \$31.82, the average valuation per ton \$31.28, and the percentage difference 1.73. Nitrogen in fine tankage has cost on the average 20.34 cents, while nitrogen in coarse tankage has cost 15.25 cents per pound. Two samples have shown a commercial shortage of over 50 cents per ton.

Dissolved Bone. — Two samples of dissolved bone have been analyzed and both were up to the guarantee placed upon them. The average retail cash price per ton has been \$29.67, the average valuation \$26.17, and the percentage difference 13.37.

Dry Ground Fish. — Twenty-three samples of dry ground fish have been examined, of which 5 were found deficient in nitrogen and 4 in phosphoric acid. The average retail cash price per ton was \$39.65, the average valuation \$38.89, and the percentage difference 1.95. Nitrogen from dry ground fish has cost on the average 20.39 cents per pound. Two brands have been analyzed, which show a commercial shortage of over 50 cents per ton.

Wood Ashes. — Thirteen samples of wood ashes have been analyzed, of which 1 was deficient in potash and 2 in phosphoric acid, although none of the samples showed a commercial shortage. Three samples put out by H. C. Green & Co., importers, were simply guaranteed "Pure wood ashes." The agent for three cars of these ashes, Ross Bros. Company, Worcester, Mass., stated that the ashes were of such poor quality that no charge would be made for them. Under present conditions of price and quality, the purchase of wood ashes is of questionable economy. They should never be bought without a guarantee of potash, phosphoric acid and lime.

Ground Rock. — The Farmhood Corporation of Boston, Mass., has offered a product called "Farmfood" which is unquestionably a ground mineral. It was guaranteed 2 per cent. phosphoric acid and 5 per cent. potash, both "in bond," meaning presumably associated with silica and not soluble. An analysis reveals the presence of 2.55 per cent. phosphoric acid, of which only .38 per cent. was available (dissolved by neutral citrate of ammonia). Only .56 per cent. of potash was found soluble in boiling water, and only .66 per cent. was found soluble in dilute hydrochloric acid. The commercial value of the product was \$1.65 per ton, which would hardly pay cartage.

The New England Mineral Fertilizer Company¹ of Boston, Mass., has put out a product called "New England mineral fertilizer," which is apparently largely ground rock. The material was guaranteed .23 per cent. phosphoric acid and 1.50 per cent. potash. Our analysis showed .18 per cent. phosphoric acid, .10 per cent. water-soluble potash and .35 per cent. potash soluble in dilute hydrochloric acid. The plant food in a ton of this material is valued at 24 cents, although \$17 is the advertised price in ton lots. Aside from the guarantee of potash and phosphoric acid, the firm makes a claim for a given percentage of soda, lime, magnesia, iron, sulfur, silica, chlorine and alumina. Although some of these elements are essential to the growth of plants, yet they are found in most soils in sufficient quantities to meet the needs of growing vegetation, so that they

¹ The New England Mineral Fertilizer Company, 19 Exchange Place, Boston, should not be confused with the New England Fertilizer Company, 40 North Market Street, Boston. The latter is an old company which has done business in Massachusetts for many years, and disclaims any connection with the New England Mineral Fertilizer Company.

have no particular significance in this connection. The extravagant claims made by the company for this "New England mineral fertilizer" are overdrawn, and border somewhat upon the ridiculous.

NITROGEN COMPOUNDS. — *Sulfate of Ammonia.* — Two samples of sulfate of ammonia have been analyzed and found well up to the guarantee. The average cost of the pound of nitrogen in this form has been 15.65 cents.

Nitrate of Soda. — Sixteen samples of nitrate of soda have been analyzed and only 1 was found deficient in nitrogen. The average cost of nitrogen per pound in this form has been 16.56 cents.

Dried Blood. — Three samples of this material were examined, 2 of the brands showing a considerable overrun and 1 a slight deficiency in nitrogen, the latter containing, however, considerable phosphoric acid. The average cost of nitrogen from blood has been 20.16 cents per pound.

Castor Pomace. — Six samples of castor pomace have been inspected and the guarantee was maintained in each instance. The average cost of nitrogen in this form has been 22.29 cents per pound.

Cottonseed Meal. — Nineteen samples of cottonseed meal used for fertilizer have been examined. These were licensed by 6 companies doing business in Massachusetts. Nitrogen from cottonseed meal has cost on the average 28.47 cents per pound. Seven out of the 19 samples analyzed showed a commercial shortage amounting to over 50 cents per ton.

POTASH COMPOUNDS. — *Carbonate of Potash.* — Only 1 sample of carbonate of potash was analyzed during the season. It sold so that the pound cost of actual potash was 7.54 cents.

High-grade Sulfate of Potash. — Nine samples of high-grade sulfate of potash have been examined and the potash guarantee was maintained in every instance. The pound of actual potash in this form has cost, on the average, 4.64 cents.

Potash-magnesia Sulfate. — Seven samples of double sulfate of potash and magnesia have been examined, and all have been found well up to the guarantee. The pound cost of actual potash in this form has been 5.46 cents.

Muriate of Potash. — Eleven samples of muriate of potash

have been examined, and only 1 deficiency was found. The pound of actual potash as muriate or chloride has cost on the average 4.06 cents.

Kainit. — Two samples of kainit have been analyzed and found well up to the guarantee. The pound of actual potash from kainit has cost 4.21 cents.

PHOSPHORIC ACID COMPOUNDS. — *Dissolved Bone Black.* — Three samples of dissolved bone black have been examined. Two of these were found somewhat low in available phosphoric acid, although only 1 showed a commercial shortage of over 50 cents per ton. The pound of available phosphoric acid from this source has cost, on the average, 5.91 cents.

Acid Phosphate. — Ten samples of acid phosphate have been examined, all but 3 being found well up to the minimum guarantee. No commercial shortages of over 50 cents per ton were noticed. The pound of available phosphoric acid from acid phosphate has cost 5.76 cents.

Basic Slag Phosphate. — Five samples have been analyzed, and the phosphoric acid ran low in 2 instances. There were no commercial shortages of over 50 cents per ton. The pound of available phosphoric acid (by Wagner's method) from basic slag has cost, on the average, 5.01 cents.

The complete results of the fertilizer inspection may be found in Bulletin 135.

Miscellaneous Work.

During the early part of the year some two months were devoted to the detailed mineral analysis of asparagus roots, in connection with fertilizer experiments carried on by the agricultural department. There has also been examined a number of cases of abnormal soils due to over-fertilization; such conditions are found particularly in greenhouse and tobacco soils, and in the latter case is confined to soils possessing an impervious subsoil, which will not permit of the free circulation of soluble saline materials.

In addition to the above work the fertilizer section has analyzed home mixtures, chemicals, by-products, soils, insecticides, etc., for farmers and farmers' organizations. We have insisted that all such material be taken according to furnished directions, which is more likely to insure representative sam-

ples, without which an analysis is of little value. In case of soils, but few complete detailed analyses have been made, and those only when abnormal conditions pointed to malnutrition or over-fertilization. In many cases tests were made to determine the relative amount of organic matter present and the acidity. Advice as to the use of fertilizer on any particular soil has been based more particularly upon the general character of the soil, previous manurial treatment, crop rotation, cultivation, and upon the crop to be grown.

In the analysis of by-products, refuse salts and materials used as fertilizers, the report has included the relative commercial value of the material and the best method of utilizing the same. During the year 300 miscellaneous analyses were made for citizens of the State and for the various departments of the experiment station. They may be grouped as follows:—

Fertilizers and by-products used as fertilizers,	223
Soils,	44
Miscellaneous materials,	33
<hr/>	
Total,	300

As in the past, co-operative work was done in connection with the study of new methods of analysis for the Association of Official Agricultural Chemists. Much time and study were also given to perfecting a suitable method to determine the relative availability of nitrogen from organic sources in mixed fertilizers. Tests were also made on 80 brands of fertilizer selected from the 1910 official collection, to ascertain the efficiency of the improved alkaline-permanganate method in detecting the presence of low-grade organic ammoniates.

6. REPORT OF THE FEED AND DAIRY SECTION.

Mr. P. H. Smith reports:—

The Feed Law.

During the past year 1,055 samples of feedstuffs have been collected by Mr. James T. Howard, official inspector. These samples have been analyzed and are soon to be published, together with the necessary comments.

Analytical Work.—The analytical work has consisted of

protein and fat determinations on all samples, a fiber estimation in many cases and a microscopic examination when further information seemed desirable. A protein and fat guarantee are required by law. It is felt, however, that the protein and fiber content of a feedstuff are a much better index of its true value. Protein is the most valuable constituent, while fiber is of least value, and it is a fact that any feedstuff which contains a relatively high fiber percentage is quite apt to contain some inferior by-product. For this reason more fiber determinations have been made this year than ever before.

Compliance with the Law.—Fewer violations of the law have been noted than in previous years. Reputable manufacturers and dealers are coming to believe that the statute works no hardship in honest products. The time is not far distant when to neglect to brand a feedstuff will make the purchaser suspicious of its merits. In the future, violations of the feedstuffs law will be placed in our attorney's hands for settlement. In several instances this has already been done, and one case, where goods were not guaranteed, has been taken into court. The dealer entered a plea of guilty and the case was placed on file. It is not the intention of those having the enforcement of the law in charge to be overbearing in regard to this matter, but any law which is not enforced soon becomes inoperative. The benefits of the law are so obvious as to render it unwise to allow it to become a dead letter.

New Law.—At the time the present law was passed it was not possible to secure the requirement of a fiber guarantee. Since that time other States have enacted statutes which not only require a protein, fat and fiber guarantee on all feedstuffs, but in addition a statement of composition in the case of all compounded feeds. It is believed that Massachusetts should enact a law requiring every package of feedstuff sold or offered for sale to have attached the following information:—

1. The number of net pounds in the contents of the package.
2. Name, brand or trademark.
3. Name and principal address of the manufacturer or jobber responsible for placing the commodity on the market.
4. Its chemical analysis expressed in the following terms:

(a) minimum percentage of crude protein; (b) minimum percentage of crude fat; (c) maximum percentage of crude fiber.

5. If a compounded or mixed feed, the specific name of each ingredient therein.

A revision of the present statute is now under consideration which will include the above requirements, together with such changes as have from time to time suggested themselves.

Definitions. — At present there is more or less confusion between different States and different sections of the country in regard to names of commercial feedstuffs. A feedstuff which is recognized by one name in the west may be known by an entirely different name in the east. Again, manufacturers of low-grade goods often attach names which are misleading or at best mean nothing. The National Association of Feed Control Officials is considering uniform definitions for the different commercial feedstuffs. Such a group of definitions, if adopted by the feed control officials of the different States, will be of great benefit to the retailer and manufacturer.

Weight of Sacked Feeds. — There is a growing tendency on the part of some manufacturers to state the gross weight of a package instead of the weight of the contents. Others state both net and gross weights. The State law calls for the weight of the contents of the package. Purchasers who buy sacked feeds should see that they are getting full weight. The difference between gross and net weight will amount to about 1 pound per sack.

Co-operation. — It is a difficult matter to enforce the provisions of the feedstuffs law without the co-operation of both retailers and consumers. Consumers should refuse to buy goods which are not guaranteed, and retailers should refuse to handle goods which are received without a guarantee.

The Dairy Law.

The work required by this act is divided into three natural subdivisions: (1) the examination of candidates, (2) the testing of glassware, and (3) the inspection of machines.

(1) *Examination of Candidates.* — During the past year 10 candidates were examined for proficiency in the Babcock test.

All candidates are refused a certificate who fail to show proficiency in manipulation or who do not have a good working knowledge of the principles underlying the test. Eight candidates passed the examination at the first trial, and 2 certificates were withheld until further proficiency was acquired. The idea has been prevalent that the experiment station gives instruction in Babcock testing. Such is not the case; all candidates must, before presenting themselves for examination, have acquired a thorough knowledge of the test.

(2) *Examination of Glassware.*—During the past year 4,047 pieces of glassware were examined, of which 41 pieces, or 1.01 per cent., were inaccurate. This is the lowest percentage of inaccuracy found during the ten years that the law has been in force. Following is the summary of the work for the entire period:—

YEAR.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
Totals,	29,686	1,885	6.34 ¹

The passage of this law has prevented 1,885 pieces of inaccurately graduated glassware, representing 6.34 per cent. of the entire number tested, from coming into use.

(3) *Inspection of Babcock Machines.*—Since the 1909 inspection 1 creamery has suspended operations. During the present inspection, recently completed, 28 places were visited, of which 15 were creameries, 12 milk depots and 1 a chemical laboratory. Ten of the creameries were co-operative and 5

¹ Average.

were proprietary. The 12 milk depots were in every case proprietary. Twenty-eight machines were examined, 2 of which were condemned, but on second inspection a few weeks later they were found to have been put in good condition. Those in use are 10 Facile, 6 Agos, 5 Electrical, 4 Grand Prize, 2 Wizard, 1 unknown. The glassware was, as a whole, clean, and with two exceptions Massachusetts tested. Where untested glassware was found in use, the provisions of the law were made plain, and it is not expected that there will be a repetition of the offense. Unless machines are set on firm foundation and the bearings kept well oiled, the required speed cannot be maintained economically, and machines will not give satisfaction. The Babcock machine should be as carefully looked after as the cream separator in order to give efficient service.

The creameries and milk depots where machines were inspected are as follows: —

1. Creameries.

LOCATION.	Name.	President or Manager.
1. Amherst,	Amherst,	W. A. Pease, manager.
2. Amherst,	Fort River, ¹	E. A. King, proprietor.
3. Ashfield,	Ashfield Co-operative, . .	Wm. Hunter, manager.
4. Belchertown, . . .	Belchertown Co-operative, .	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington, . . .	Cummington Co-operative, .	D. C. Morey, manager.
7. Egremont,	Egremont Co-operative, . .	E. A. Tyrrell, manager.
8. Easthampton, . . .	Hampton Co-operative, . .	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company,	W. C. Solomon, proprietor.
11. Monterey,	Berkshire Hills Creamery, .	F. A. Campbell, manager.
12. New Salem, . . .	New Salem Co-operative, .	W. A. Moore, president.
13. North Brookfield, .	North Brookfield, . . .	H. A. Richardson, proprietor.
14. Northfield,	Northfield Co-operative, .	C. C. Stearns, manager.
15. Shelburne,	Shelburne Co-operative, .	I. L. Barnard, manager.
16. Wyben Springs, . .	Wyben Springs Co-operative, .	H. C. Kelso, manager.

¹ Pays by test. Testing done at Massachusetts Agricultural Experiment Station.

2. Milk Depots.

LOCATION.	Name.	Manager.
1. Boston,	D. W. Whiting & Sons,	Geo. Whiting.
2. Boston,	H. P. Hood & Sons,	W. N. Brown.
3. Boston,	Boston Dairy Company,	W. A. Graustein.
4. Boston,	Boston Jersey Creamery,	T. P. Grant.
5. Boston,	Walker-Gordon Laboratory,	G. Franklin.
6. Boston,	Oak Grove Farm,	C. L. Alden.
7. Cambridge,	C. Brigham Company,	J. R. Blair.
8. Cheshire,	Ormsby Farms,	W. E. Penniman.
9. Dorchester,	Elm Farm Milk Company,	J. K. Knapp.
10. Sheffield,	Willow Brook Dairy,	L. C. Smith.
11. Southboro,	Deerfoot Farm Dairy,	S. H. Howes.
12. Springfield,	Tait Bros.,	W. A. Pease.
13. Springfield,	Emerson Laboratory,	H. C. Emerson.

Milk, Cream and Feeds sent for Free Examination.

During the past year the experiment station has analyzed a large number of samples of dairy products and feedstuffs sent for examination. Such work, where the results are of general interest, is a legitimate part of the station work. The station will not, however, act as a private chemist for manufacturers. Correspondence is solicited before samples are shipped, as in many cases the required information can be furnished without resorting to a chemical analysis, which will save shipping expenses to the applicant and the expense of a costly analysis to the experiment station. Upon application, full instructions for sampling and directions for shipping will be furnished, which will often obviate the necessity of sending another sample for analysis in place of one improperly taken.

Analysis of Drinking Water.

During the past year 101 samples of drinking water have been analyzed for residents of the State. The greater part of these were farm supplies where pollution was suspected. On reporting an analysis, suggestions are in all cases made as to

improving the supply when necessary. Parties wishing for water analysis should observe the following points:—

1. Application should be made for analysis.
2. A fee of \$3 is charged for each analysis, payable with the application.
3. Only samples of water received in experiment station containers are analyzed (containers sent on application).
4. The experiment station does not make bacteriological examinations.
5. The experiment station does not undertake a mineral examination of waters for medicinal properties.

Miscellaneous Work.

In addition to the work already described, this section has conducted investigations and made other analyses as follows:—

1. It has co-operated with the Association of Official Agricultural Chemists in a study of the methods for the determination of acidity in gluten feeds.
2. It has co-operated with the officials of the New England Corn Exposition in making analysis of corn in connection with the awarding of prizes.
3. It has co-operated with the Bowker Fertilizer Company in making analyses of corn in connection with the awarding of prizes.
4. It has arranged and furnished exhibits and speakers in co-operation with the extension department for (a) the better farming special; (b) the better farming trolley special; (c) an exhibit for several of the Massachusetts fairs; (d) an exhibit for the New England Corn Show.
5. It has conducted an investigation in connection with cases of alleged arsenic poisoning of horses through eating sulfured oats, with negative results.
6. In connection with the experimental work of this and other departments of the experiment station, this section has made analyses of 247 samples of milk, 115 samples of cattle feeds and 300 samples of agricultural plants.

Testing of Pure-bred Cows.

The work of testing cows for the various cattle associations continues to increase. Such work is a tax upon the time of the head of this section, and, owing to the uncertainty of steady employment, it is often difficult to secure men to do the work. Two men are now employed permanently in connection with the Jersey, Guernsey and Ayrshire tests. The rules of the above associations require the presence of a supervisor once each month for two consecutive days at the farms where animals are on test. The milk yields noted by the supervisors at their monthly visits are used in checking the records reported by the owners to the several cattle clubs. The Babcock tests obtained at that time are likewise reported, and used as a basis for computing the butter fat yield for each month. Up to June 1, 1910, the supervisors were only required to spend one day in testing Guernsey cows. At the annual meeting of the American Guernsey Cattle Club, in May, 1910, the rules were changed so as to require a two-day monthly test. While this practically doubles the work for this breed, it is felt that a two-day basis is much more accurate in computing tests.

During the past year 1 214-day test and 44 yearly tests with Guernsey cows, 10 7-day and 88 yearly tests with Jersey cows, and a number of yearly tests with Ayrshire cows have been completed.

The Holstein-Friesian tests usually cover periods of from 7 to 30 days, and require the presence of a supervisor during the entire test. During the past year 16 different men have been employed at different times in conducting these tests, which give rather irregular employment during the winter months. On account of the uncertainty of the work such men are difficult to obtain, but thus far it has not been necessary for the experiment station to refuse an application. For the Holstein-Friesian association 112 7-day, 5 14-day, 11 30-day, and one semi-official year test have been completed.

There are now on test for yearly records 96 Jersey, 28 Guernsey and 8 Ayrshire cows.

REPORT OF THE BOTANIST.

G. E. STONE.

The routine and research work of the botanists and assistants for the past year followed similar lines to those of other years, except that perhaps the routine work has had a tendency to increase, leaving less time for research work. This has been remedied to a considerable extent, however, by the addition of Mr. Sumner C. Brooks as laboratory assistant. Mr. Brooks was graduated from the class of 1910, and his appointment as assistant relieves Mr. Chapman of much routine work and gives him time for research, for which he is well fitted. Miss J. V. Crocker has, as usual, been of much service in attending to the correspondence and records, and has given valuable assistance in the seed testing. Much assistance has, as formerly, been obtained from the undergraduate students, and Mr. E. A. Larrabee and Mr. Ray E. Torrey have devoted all their spare time to the department, and were employed during the whole summer vacation.

DISEASES MORE OR LESS COMMON DURING THE YEAR.

The season of 1910 opened unusually early, as is shown by the meteorological records and by the blossoming of trees, shrubs and flowers. The season was, on the whole, rather dry, and crops suffered to some extent from drought, a condition which was emphasized by the severe droughts of the two preceding years.

The peach leaf curl, which naturally follows a cold and rainy period, was quite common. Some frost occurred in May, and in some localities it was reported in June. The effects of this showed on asparagus, and frost blisters were common on apple foliage. An unusually large amount of apple foliage was sent in to this department for examination in early sum-

mer. This was affected not only with frost blisters, but considerable injury was caused by a mite, the effect being in many cases similar. An early outbreak of apple scab was also noticed on apple foliage.

Strawberries were of poor quality, and considerable rot of the fruit occurred, owing to excessive rainfall. The foliage of rock maples and oaks was affected to an unusual extent with *Glœosporium*. In many sections maples in general were affected with this fungus, causing a browning of the leaf and much defoliation, and many inquiries were received concerning this trouble.

Some of the diseases which were more common are as follows: hollyhock rust, sweet pea trouble, apple rust, hawthorne rust, quince rust, black rot of grapes, crown gall, sycamore blight, blossom end rot of tomatoes, pear blight and pear scab, corn smut and maple leaf spot (*Rhytisma*). Considerable interest is also manifest in the chestnut disease, which is becoming more noticeable in this State.

The following is a list of the less common diseases reported during the year: ash rust, bean rust, rose rust, pea mildew, rose mildew, currant Anthracnose, Anthracnose of melon, rust on strawberry leaves, cherry leaf spot (*Cylindrosporium*), potato rot, horse chestnut blight (*Phyllosticta*), apple scab, cane blight of raspberries (*Coniothyrium*), blackberry Anthracnose and cherry leaf blight (*Cercospora*). Besides these may be mentioned troubles with which no organisms are associated, namely, frost blisters, frost effect on asparagus, sun scald and sun scorch, malnutrition of cucumbers and aster yellows.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD.

The year 1910 has been marked by numerous changes in this department. The resignation of Prof. C. H. Fernald in June, as station entomologist, marks the first change in the head of this portion of the station work since the department was established in 1888. The resignation, at the same time, of Mr. J. N. Summers from his connection with the station, and the poor health of the writer during the early part of the year, necessarily seriously affected the work accomplished, and the time taken in the fall by moving into new quarters has practically prevented anything besides routine work.

The development of a new line of investigation has been made possible by the appointment of Dr. B. N. Gates as station apiarist. Dr. Gates's work will be, at least for the present, entirely under the Adams fund.

Mr. Arthur I. Bourne has been appointed assistant in entomology, and is, in general, in charge of the correspondence and of considerable of the experimental work. His appointment will enable the head of the department to devote more time to the larger problems relating to insects in this State, both in general and in connection with Adams fund projects, than has heretofore been the case.

It has proved to be impossible to obtain an orchard near the station in which to continue the observations on the size and importance of the different broods of the codling moth. The movement for better fruit in Massachusetts has been nowhere more evident than in Amherst, and the results, though most desirable in general, have been disastrous for the continuation of this series of observations, which must now be discontinued. A long delay in moving the greenhouse to its new site, and in making it ready for use, has prevented taking up this year the

experiments on the resistance of muskmelons to fumigation. These can be resumed during 1911, however.

Further tests of methods of controlling wire worms attacking seed corn have been continued on Mr. Whitcomb's farm. The results of the tests already made were referred to in the last report, and were also published in the "Journal of Economic Entomology" for August, 1909. It was distinctly stated in the latter publication that these methods were still in the experimental stage, but that it seemed desirable to test them on a larger scale in different parts of the country. Several of the agricultural papers suggested this to their readers, and the reports received as to results varied from excellent to failure, by preventing germination. A few cases of failure have been investigated, and in every case so far appear to have been due to the use of coal tar instead of gas tar, or to giving the corn such a heavy coating of the tar as to, of itself, prevent germination. On the whole, the treatment can hardly be considered as having been fairly tested in all cases.

One objection to the method is that the seed must be treated first with tar and then with the Paris green. During the past season it has been attempted to avoid this, while obtaining equally good results, by the use of arsenate of lead. The particular brand used in these experiments was disparene, which comes in paste form. This was diluted till about as thick as paint. Then the corn was added and the whole thoroughly stirred. The corn was then spread out till dry.

Unfortunately, wire worms proved to be few in the fields where the treated corn was planted, so that the value of the test was restricted to a determination of the effect of the treatment on the germination of the seed. From this standpoint, however, it was a success, having no injurious effect whatever. Plans have already been made to continue this work another season, and fields badly infested with wire worms are to be made use of, so far as these can be found.

Dates of the hatching of the young of the oyster-shell scale, the scurfy scale and the pine-leaf scale have been continued as far as possible. The object of this has been stated in previous reports, and it need only be added here that the observations

should be continued for several years, if averages of value are to be obtained.

Nearly ten years ago a study of the Marguerite fly, a pest too familiar to many florists, was begun, but was soon dropped for lack of material. More having been obtained, this investigation has been resumed, and it is hoped that the entire life history of the fly may now be learned, together with effective methods for its control.

Observations on the distribution limits of insect pests in Massachusetts have been continued as opportunity has offered, and some interesting facts on this subject have been obtained. Work of this kind must, from its very nature, be fragmentary for a long time, and for years the gathering and preservation of the observations made are all which it will be possible to accomplish. As the time required for this is but a few moments per week, or even per month, however, the results are well worth the trouble.

Investigations on the importance of the Sphecidae as parasites have been continued, and a number of additions to our knowledge of the group have resulted. The subject is a large one, however, and the amount of time available for this purpose has been much less than could be desired. Experiments with insecticides have been almost at a standstill from their entomological side, waiting for pure materials of known composition to be provided by the chemical department. Some of these have been satisfactorily obtained during the fall and the tests of them can be begun in the spring of 1911. The chemical results of this work will be reported upon by that department.

CHARLES ANTHONY GOESSMANN.

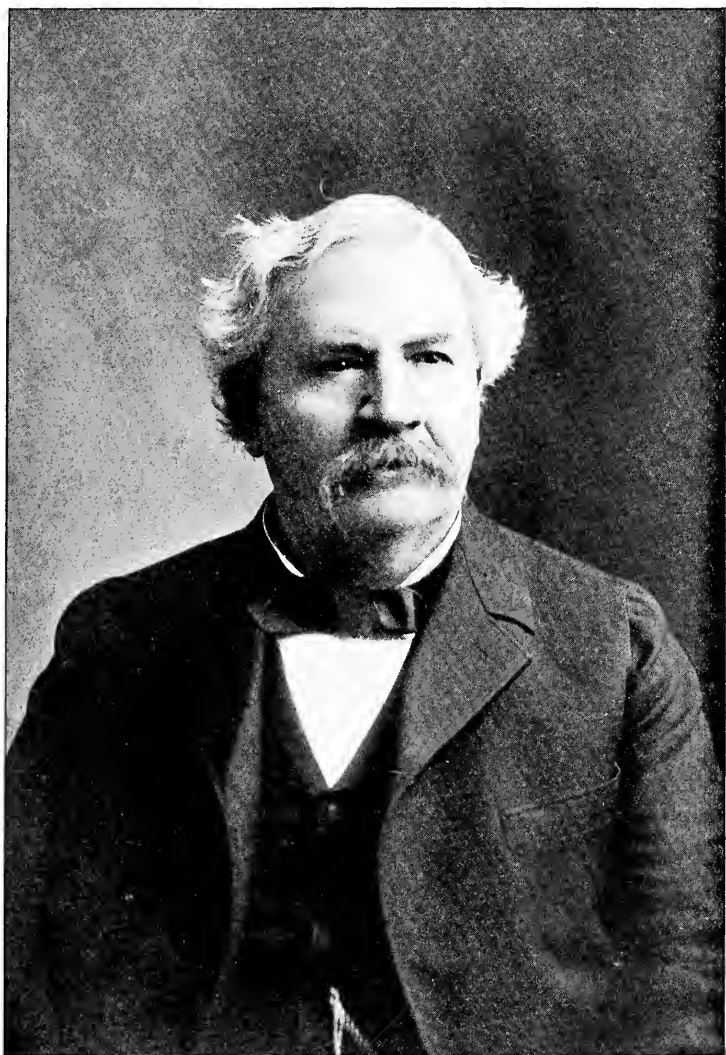
Charles Anthony Goessmann, chemist, investigator, teacher and philosopher, passed to the higher life Sept. 1, 1910.

Karl Anton Gössmann was born in Naumburg, in the Grand Duchy of Hesse, Germany, June 13, 1827. He was the son of Dr. Heinrich Gössmann, who was a fellow student of the noted chemist Frederick Wöhler. When the boy was seven or eight years of age the family moved to Fritzlar in Hesse and here young Gössmann spent his boyhood days. His father wished his son to become a pharmacist, and he received training in pharmacy previous to his becoming a university student. He entered the university of Göttingen in 1850, and studied chemistry, botany, physics, geology and mineralogy. He received the degree of Doctor of Philosophy in 1851 for a dissertation on the "Constituents of the Cantharides." Wöhler early recognized the ability and industry of the young chemist, and made him assistant in his laboratory, and upon the appointment of Limpricht to a professorship, Gössmann became a privatdocent and Wöhler's first assistant. He assumed charge of the chemical laboratory, and lectured on organic and technical chemistry as well as to students of pharmacy. His American students during the period were Chandler, Marsh, Joy, Nason, Caldwell and Pugh.

During his stay at Göttingen he received a number of flattering offers from other institutions, and made the acquaintance of Schönbein, the chemical physicist who discovered gun cotton and ozone; of Schrötter, noted for his researches in phosphorus; of A. W. von Hoffmann and of the celebrated French chemist Sainte Clair Deville.

In 1857 Gössmann left Göttingen on leave of absence, and visited the universities and a number of manufacturing establishments in Germany, Austria, France and England, and then journeyed to the United States upon invitation from Eastwich Brothers in order to become scientific director of their large sugar refineries. It was his intention eventually to return to Germany and teach technical chemistry, but he became so interested in the new country, and observed such a wide field of future usefulness for the technical chemist, that he decided to make the United States his permanent home.

After completing his work at Philadelphia he went to Cuba in order to study the methods of handling sugar then in vogue. On returning to the United States he was engaged as chemist by the Onondaga Salt Company of Syracuse, a position which he retained until 1869.



C. A. Eversmann

BORN JUNE 13, 1827. DIED SEPT. 1, 1910.

[Brief sketch of life, page 80.]

While in its employ, he visited and examined the salt springs in Canada, Michigan and Louisiana. During the latter part of this Syracuse period he spent a portion of each year as professor of chemistry and physics at the Rensselaer Polytechnic Institute at Troy, and he was invited to occupy the position permanently.

In 1868, at the earnest solicitation of his friend, the late Col. William S. Clark, he accepted the professorship of chemistry at the Massachusetts Agricultural College, and held it continuously until his retirement in June, 1907. He was placed at the head of the Massachusetts Experiment Station, a private enterprise started in 1878, and was instrumental in securing the establishment of the Massachusetts State Agricultural Experiment Station in 1882, being made its director and chemist, — positions which he held until it was merged with the Hatch Experiment Station by act of the Legislature in 1895.

Professor Goessmann served as chemist to the Massachusetts State Board of Agriculture from 1873 until his retirement, and for many years also acted as associate analyst of the Massachusetts State Board of Health. He became the first president of the Association of Official Agricultural Chemists, and was a charter member of the American Chemical Society, which he also served as president and vice-president. He was a member of the German society of naturalists and physicians, of the Physico-Medical Society of Erlangen University, a fellow of the American Association for the Advancement of Science, and a member of the Massachusetts Horticultural Society and of the Massachusetts Meteorological Society.

In 1889 Amherst College conferred upon him the degree of Doctor of Laws.

In this connection space forbids any extended reference to his work. Briefly it may be classified into four periods:—

1. The Göttingen Period of Seven Years, 1850–57.

In addition to his work as teacher in the university he found time to make and publish the results of twenty-five distinct investigations, all of which may be found in the "*Annalen der Chemie u. Pharmacie.*" Among the most important of these papers may be mentioned the discovery of arachidic and hypogæic acids in the peanut oil, the constituents of the cantharides, the composition of cocoa oil and the constitution of leucine. This latter paper was considered of so much importance that it drew forth a letter of commendation from Wöhler to Dumas and secured for Gössmann membership in the Physico-Medical Society of the University of Erlangen, an honor which he highly prized.

2. *The American Period of Eleven Years previous to the Massachusetts Agricultural College, 1858-69.*

He made a number of contributions to the "American Journal of Science" on the chemistry of brine and salt, and while in the employ of the salt company at Syracuse devised a process for the removal of calcium and magnesium chlorides from salt which was of inestimable value to the salt industry of the United States. He also contributed papers to the "London Chemical News" on sugar refining.

3. *The Massachusetts First Period, 1869-86.*

During this period, in addition to teaching, Professor Goessmann made a study of the agricultural conditions in the State, was a frequent contributor to the agricultural press, and gave numerous lectures before the State Board of Agriculture.

His more prominent investigations may be briefly referred to under the following headings:—

(a) *Beets for Sugar, and Sugar Beets as an Agricultural Enterprise.*—He carried on investigations with the sugar beet both in the field and laboratory, and demonstrated the feasibility of growing beets for sugar in certain sections of Massachusetts, and concluded that, with the proper education of the farmer and capitalist, the production of sugar from the beet should prove a profitable American industry. (Reports of the Massachusetts Agricultural College, 1871, 1872, 1873, 1874, 1876.)

(b) *The Value of Early Amber Sorghum as a Sugar-producing Plant.*—His study of the plant as a possible source of sugar led him to conclude that "the presence of a large amount of grape sugar in all the later stages of growth . . . is a serious feature in the composition of the juice, impairing greatly the chances for a copious separation of the cane sugar by simple modes of treatment." *This prophesy has been literally fulfilled*, in spite of the later efforts to utilize this plant as a commercial source of sugar.

(c) *Reclamation of Salt Marshes.*—Goessmann made a thorough investigation of the condition of the marshes in southeastern Massachusetts, and embodied his results in a number of valuable papers before the Massachusetts State Board of Agriculture. His studies included the chemical conditions of the soils, and he recommended diking when necessary, suitable fertilizers and especially thorough drainage and cultivation. (Reports of the Massachusetts State Board of Agriculture, 1874, 1875, 1876.)

(d) *The Application of Chemistry to Fruit Culture.*—His studies were devoted particularly to the composition of the ash of different fruits, and to the influence of the various forms of mineral fertility upon yield and quality. He emphasized the need of a thorough study of the functions of the several mineral elements in plant growth, a

subject still calling for much careful investigation. He proved to his own satisfaction that muriate of potash promoted particularly the growth and improved the quality of fruit; and, further, that an increase of potash was accompanied by a corresponding decrease in lime and phosphorus. He called attention to the fact that the young branches of peach trees affected with "yellows" contained excessive amounts of lime and phosphoric acid, and that a judicious pruning, together with liberal applications of muriate of potash, restored the affected trees to a vigorous growth, which contained normal amounts of potash, lime and phosphoric acid. (Twenty-seventh and thirty-second reports of the Massachusetts State Board of Agriculture.)

(e) *The Chemical Composition of Different Varieties of Corn, and the Preservation of Corn in Silos.* — Goessmann gave considerable attention to the value of corn for cattle, and in a comprehensive paper published numerous analyses of different varieties of the entire corn plant, as well as of the stalks, ears and cobs. About 1880 attention was being given to the method of preserving corn in the silo, and the claim was made by Dr. J. M. Bailey and others that corn thus preserved (ensilage) did not suffer loss by the process, but was actually superior in feeding value to the original product. Goessmann in two admirable papers explained and discussed the principles of animal nutrition founded upon the researches of German investigators, showed the place of corn in the animal economy, pointed out the changes that took place during the process of fermentation, and made clear the relative merits of the dry and preserved corn. His statements concerning the relative value of silage and dry corn, made in 1880, hold true at the present time. (Reports of the Massachusetts State Board of Agriculture, 1879-80, 1880, 1881.)

(f) *The Inspection of Commercial Fertilizers.* — Goessmann was instrumental in securing the passage of a law authorizing the inspection of commercial fertilizers, which became operative Oct. 1, 1873, and as State Inspector of Fertilizers under the new law he made a preliminary report the same year. (Twenty-first report of the Massachusetts State Board of Agriculture.) It is believed that this was the first law enacted in the United States requiring an official inspection of fertilizers. He found many of the materials offered to be of uncertain composition, and to vary greatly in price; "these same articles cost the farmers . . . about one-half the amount more than they ought to". His work along this line from year to year corrected most of these abuses, and was unquestionably of great pecuniary value to the farmers of the State and nation.

4. *The Massachusetts Second Period, 1886-1907.*

The Massachusetts State Agricultural Experiment Station was established by act of the State Legislature, and Goessmann was made

director and chemist. The yearly grant of \$5,000 was soon increased to \$10,000, and in 1885-86 a new chemical laboratory was completed. He relinquished most of his college work, and devoted his energies to a thorough organization of the station.

The chief lines of work pursued by the station under his guidance are mentioned under the following general headings:—

1. The free analyses of fertilizers, refuse materials suitable for fertilizing purposes, coarse and concentrated feeds and drinking waters.

2. Experiments with dairy cows to test the relative feeding values of home-grown fodders and of commercial feedstuffs.

3. Feeding experiments with soiling crops, and the introduction and testing of new fodder crops.

4. Experiments with pigs to determine the rations best suited for pork production.

5. Feeding experiments with steers and sheep to determine the cost of beef and mutton, and to study the rations best suited for such purposes.

6. Field experiments to determine the nitrogen-acquiring power of the legumes.

7. Field experiments to study the best fertilizer combinations for market-garden crops.

8. Field experiments to ascertain the relative values of different forms of phosphoric acid.

9. Fertilizers best suited for permanent grass lands.

10. The effects of various forms of plant food in modifying the quality of the product.

11. Compilation of tables of analyses of fertilizers, cattle feeds, dairy products and fruits made at the station.

He devoted himself to the executive work of the station, and carefully supervised all of the experimental work as well. While not a rapid worker, he succeeded in accomplishing a great deal because of his steady and long-continued application. Since 1886 practically all of his papers were published in the annual reports of the experiment station.

After the merging of the State and Hatch stations, in 1895, advancing years made it necessary for him to relinquish many of his responsibilities. He continued, however, until his retirement to supervise the inspection of fertilizers and the general work in the fertilizer and soil laboratory.

Aside from his services as investigator and teacher, it is important to remember that he inspired in others a zeal for further study and accomplishment. There are to be found among his pupils presidents of colleges and schools of agriculture, directors of experiment stations, research and technical chemists, teachers, as well as workers in many lines of industry having a direct bearing upon agriculture.

Professor Goessmann possessed a wonderfully retentive memory, and being a great reader he was especially well informed on a wide variety of topics. He was a good conversationalist, and if interested in a subject poured forth a torrent of information, interspersed with opinions of his own. He had a genial disposition, a winning personality, and when he was amused his smile of appreciation was not soon to be forgotten. One did not need to be long associated with him to feel his influence for good and to realize that he was much more than an ordinary man. In fact, his very presence seemed to exhale a sort of spiritual essence which lifted one to a higher level of thought and feeling.

Goessmann was indeed a pioneer in the cause of agricultural investigation in the United States, or, as one of his students expressed it, he was a foundation builder. He was a leader, and pointed the way to a fuller understanding of the principles of science as applied to agriculture. Every experiment station worker, every tiller of the soil, and in fact every citizen in our great country, either directly or indirectly, has been benefited by this man who has recently passed into the Great Beyond.

J. B. LINDSEY.

STUDIES IN MILK SECRETION.

BY J. B. LINDSEY.

THE EFFECT OF PROTEIN UPON THE PRODUCTION AND COMPOSITION OF MILK.

Investigations and observations indicate that milk is not a simple fluid secreted directly by the blood, but a complex substance resulting from the activity of the milk cells. The cells and milk glands take from the blood and lymph vessels substances suited to their purposes, and by chemical and physiological processes convert them into a different substance, namely, milk. Milk, therefore, consists for the most part of reconstructed cell substance, and it is not possible, by any system of feeding, to produce very great modification in its composition. The composition of milk depends principally upon the breed and individuality of the cow, stage of lactation and development of the milk cells.

G. Kuhn,¹ M. Fleischer¹ and E. Wolff,² during the years 1868 to 1876, studied the additions to the different basal rations of increasing amounts of protein upon the composition of the milk, and noted only very slight variations. They observed that of all the milk components the percentage of fat was the most influenced by the food supply. N. J. Fjord and F. Friis,³ as a result of experiments by the group method with 1,152 cows, concluded that the protein was practically without influence in varying the proportions of the several milk ingredients. W. H. Jordan⁴ has conducted a number of trials, and failed to note any specific influence of the protein in

¹ Landw. Versuchsstationen 12 Bd., 1869; Journal für Landw., 1874.

² Die Versuchsstationen Hohenheim, Berlin, 1870; Résumé in Die Ernährung der Landw. Nützthiere, E. Wolff, 1876.

³ Beretning fra den Kgl. Veterinær. og Landbohøjskole Lab. for landøkonomiske Forsøg. Kopenhagen, 1892; Résumé in Centralblatt f. Agricultur Chemie, 22 Jahrg., 1893. s. 604.

⁴ Maine Experiment Station, reports for 1885-86, 1886-87; New York Experiment Station, Bulletin 197, 1906.

varying the proportion of the milk constituents. Armsby,¹ as well as Whitcher and Wood,² has drawn similar conclusions. Morgan *et als.* conclude from numerous investigations that protein is without specific influence in the formation of milk fat.³ Kellner,⁴ in summing up the results of numerous experiments, especially of German origin, says "in so far as it is possible by means of food to effect the action of the milk glands, the protein of the several food groups exerts a very pronounced influence. This influence is especially noticeable in increasing the *quantity* of the milk. Only after the long-continued feeding of a ration known to be deficient in protein does the water content of the milk increase, and the dry matter and fat show a noticeable decrease."

This station from time to time has conducted a number of experiments to observe the influence of different amounts of protein in increasing the quantity of milk, to note the protein requirements of dairy animals and also to study its influence in modifying the proportions of the several milk ingredients. Some of these results have been published in reports of the station. It is proposed to briefly summarize the results already given publicity, and to describe somewhat in detail our more recent observations.

Experiment I.⁵ — 1895.

This experiment was undertaken with six cows by the reversal method. The animals were from five to ten years of age, had all calved in the early autumn, and none had been served when the experiment began.

Weighing Animals. — The animals were weighed once before feeding and watering at the beginning and end of each half of the trial, and once each week during the continuance of the experiment. It would have been better to have weighed each animal for three consecutive days at the beginning and

¹ Wisconsin Experiment Station, reports for 1885-86, New Hampshire Experiment Station, Bulletin 90, pp. 12-14; Bulletin 18, p. 13.

² *Ibid.*

³ Landw. Vers. Stat., 62 (1905), nos. 4, 5; pp. 251-286; Abs. Experiment Station Record Vol. 17, p. 286.

⁴ Die Ernährung d. Landw. Nützthiere, erste Auflage, p. 519; also, fünfte Auflage, p. 539.

⁵ Ninth report of the Hatch Experiment Station, pp. 100-125.

end of the experiment; the weights, however, were probably sufficient to give an accurate *average weight* of each animal.

Sampling and Testing the Milk. — A composite sample of each cow's milk was made for five consecutive days, and preserved with bichromate of potash. Great care was used to secure representative samples. The total solids and fat were determined by approved gravimetric methods.

Dates of the Experiment.

DATES.	Days.	High Protein.	Low Protein.
Oct. 24 through Nov. 18, 1895, . . .	26	Cows I., IV., VI.	Cows II., III., V.
Nov. 28 through Dec. 23, 1895, . . .	26	Cows II., III., V.	Cows I., IV., VI.

At least a week elapsed after the animals were placed upon full rations before the experiment proper began.

Average Daily Rations fed to the Six Cows (Pounds).

CHARACTER OF RATION.	Wheat Bran.	Chicago Gluten Meal.	Corn Meal.	Hay.	Sugar Beets.
High protein,	3	5.83	—	15.17	12
Low protein,	3	—	5.83	16.17	12

Each of the cows received 3 pounds of bran and 12 pounds of beets daily. One of the cows, Ada, received only 5 pounds of corn or gluten meal per day, while the others received each 6 pounds. The amount of hay fed differed slightly in the case of individual cows, depending upon their ability to utilize it. The hay was of good quality, containing 9.73 per cent. of crude protein; the bran 19.20 per cent.; the gluten meal 42.73 per cent., and the corn meal 11.36 per cent., all on a dry-matter basis.

It will be seen that the basal ration consisted of hay, beets and bran, and that the variable factor was the corn or gluten meal.

Average Weight of Animals and Average Digestible Nutrients in Daily Rations (Pounds).

CHARACTER OF RATION.	Weight of Animal.	DIGESTIBLE NUTRIENTS.				Nutritive Ratio.
		Protein.	Fat.	Fiber and Extract Matter.	Total.	
High protein,	941	3.07	.59	10.23	14.06	1:3.86
Low protein,	938	1.46	.52	12.45	14.43	1:9.43

Three of the cows varied in weight from 800 to 900 pounds, and three others from 1,000 to 1,060 pounds. During the high-protein period the cows gained in total 101 pounds, and during the low-protein period there was a total loss of 64 pounds. The average weight of the herd during each of the two halves of the experiment was substantially the same.

The figures for digestible nutrients were secured from actual analysis of the feedstuffs used, together with average digestion coefficients, actual digestion tests not being made. The total digestible nutrients consumed was the same in case of each of the halves of the experiment, the difference being in the excess of digestible protein and the corresponding deficit of carbohydrates. The high-protein ration had evidently too narrow a ratio, and the low-protein ration too wide a ratio for the best results.

Protein Balance (Pounds).

CHARACTER OF RATION.	Cows.	Protein digested.	Protein required for Maintenance.	Protein contained in Milk (N. x 6.25).	Protein Excess over Maintenance and Milk Requirements.
High protein, . . .	Ada, . . .	69.16	14.56	20.31	34.29
	Una, . . .	79.56	16.38	18.66	44.52
	Bessie, . . .	81.12	15.60	26.03	39.49
	Beauty, . . .	84.24	18.98	22.28	42.98
	Red, . . .	82.16	19.24	24.26	38.66
	Spot, . . .	82.16	17.94	23.00	36.22
Low protein, . . .	Ada, . . .	33.54	14.56	17.84	1.14
	Una, . . .	36.40	16.12	17.84	2.44
	Bessie, . . .	37.96	15.60	22.51	— .15
	Beauty, . . .	40.82	18.98	17.92	3.92
	Red, . . .	39.00	18.72	22.08	— 1.80
	Spot, . . .	39.00	18.20	20.72	.08
Total high,	—	478.40	102.70	139.54	236.16
Total low,	—	226.72	102.18	118.91	5.63
Average per cow, high, . . .	—	79.73	17.12	23.26	39.36
Average per cow, low, . . .	—	37.79	17.03	19.82	.94

¹ Calculated by allowing .7 of a pound digestible crude protein per day per 1,000 pounds live weight.

In this experiment the percentage of protein in the milk was not determined, and the average figures secured for the experiment immediately following were employed. Calculations show that in the high-protein period there was a surplus of nearly 100 (97.5) per cent. of digestible protein over that required for maintenance and milk production, while in the low-protein period the total digestible protein consumed and the amount required were about equal.

Influence of Protein on the Milk Yield.

Herd Results in Pounds.

CHARACTER OF RATION.	Average Weight of Cow.	Yield of Milk.	Protein digested.	Protein required for Maintenance and Milk.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
High protein,	941	4,211.5	478.40	242.24	236.16	97.5
Low protein,	938	3,695.5	226.72	221.09	5.63	2.3

It is quite evident that the ration with the large excess of digestible protein exerted a marked influence on the milk-secreting organs, causing an increase of approximately 15 per cent. in the milk yield. The average daily milk product per cow during the high-protein period was 27.2 pounds, and during the low-protein period 23.7 pounds, and it therefore may be said that both rations produced a fair yield. The period was too short to note the effect of the larger amount of protein on the general condition of the animal; it is believed, however, that if such an amount had been fed for a long period of time, the result would have been over-stimulation, indigestion and a refusal to eat the large amount of gluten meal.

Effect of the Rations on the Composition of the Milk (Per Cent.).

CHARACTER OF RATION.	Total Solids.	Fat.	Solids not Fat.
High protein,	13.67	4.51	9.16
Low protein,	13.45	4.28	9.17

Composite samples of each cow's milk were secured for five days of each week. These composites were averaged, and this average represented the composition of the milk of each cow for the period. The average percentage produced by each cow was multiplied by the pounds of milk she produced, thus securing the weight of total solid matter and fat yield by each animal in the herd. These totals were added and the amount divided by the total amount of milk given by the herd, and the quotient represents the average percentage of total solids and of fat, as stated in the table.

The results indicate that during the low-protein period, the cows produced milk containing .23 per cent. less fat than in the period when the high protein was fed. The difference is not pronounced and may be considered within the limit of a reasonable experimental error.

Experiment II.¹

This experiment immediately succeeded experiment I. and was conducted with the same cows, excepting that cow II. (Una) was replaced by Guernsey. The general plan of the experiment, methods of caring for the cows, feeding and sampling of milk were all identical with the preceding experiment.

Dates of the Experiment.

DATES.	Days.	High Protein.	Low Protein.
Jan. 27 through Feb. 16, 1896,	21	Cows I., II., VI.	Cows III., IV., V.
Feb. 29 through March 20, 1896,	21	Cows III., IV., V.	Cows I., II., VI.

It will be seen that each period lasted twenty-one days, with a preliminary feeding of seven or more days.

Average Daily Rations fed to the Six Cows (Pounds).

CHARACTER OF RATION.	Wheat Bran.	Chicago Gluten Meal.	Linseed Meal.	Corn Meal.	Hay.	Millet and Soy Bean Silage.
High protein,	2.83	3.00	1.92	—	10.33	28.33
Low protein,	1.92	—	—	5.83	10.33	28.33

¹ Ninth annual report of the Hatch Experiment Station, pp. 100-125.

The bran contained 18.87 per cent., the Chicago gluten 39.75 per cent., the old-process linseed meal 41.99 per cent. and the corn meal 11.36 per cent. of protein in dry matter. The silage was a mixture of barnyard millet and soy beans, the latter being quite well podded; it contained about 81 per cent. of water and 12 per cent. of protein in dry matter. Each animal received from 9 to 11 pounds of hay, 20 to 30 pounds of silage, during each half of the experiment. In the high-protein ration from 2 to 3 pounds of bran were fed, 3 pounds of gluten and 1.5 to 2 pounds of linseed meal. In the low-protein ration 1.5 to 2 pounds of bran were given and 5 to 6 pounds of corn meal. The above table shows the averages. The cows ate their rations clean in every case.

Average Weight of Animals and Average Digestible Nutrients fed daily (Pounds).

CHARACTER OF RATION.	Weight of Animals.	Protein.	Fat.	Fiber and Extract Matter.	Total.	Nutritive Ratio.
High protein, . .	899	2.85	.65	9.96	13.46	1:4.04
Low protein, . .	900	1.45	.54	11.44	13.42	1:8.85

The individual weight of the individual cows varied from 763 to 1,004 pounds. The cows changed very slightly in weight during each half of the experiment.

The digestible nutrients were calculated from the analyses of the feed, with the aid of average digestion coefficients. The high-protein ration contained substantially twice as much digestible protein as the low-protein ration. The fat varied but slightly, and the difference in the amount of carbohydrate matter depended naturally upon the different amounts of protein fed. The total nutrients consumed in two rations were the same.

Protein Balance (Pounds).

Periods of Twenty-one Days.

CHARACTER OF RATION.	Cows.	Protein digested.	Protein required for Maintenance.	Protein contained in Milk (N x 6.25).	Protein Excess over Maintenance and Milk Requirement.
High protein, . . .	Ada, . . .	50.61	11.21	15.42	23.98
	Guernsey, . .	60.61	12.60	19.52	28.49
	Bessie, . . .	61.53	12.18	18.98	30.37
	Beauty, . . .	62.58	14.41	16.22	31.95
	Red, . . .	62.58	14.91	17.37	30.30
	Spot, . . .	62.58	13.86	20.29	28.43
Low protein, . . .	Ada, . . .	25.20	11.34	12.83	1.03
	Guernsey, . .	31.50	12.30	16.36	2.84
	Bessie, . . .	30.24	12.09	15.90	2.25
	Beauty, . . .	31.29	14.07	15.08	2.14
	Red, . . .	31.29	14.70	16.05	.54
	Spot, . . .	32.55	13.84	16.65	2.06
Total high,	-	360.49	79.17	107.80	173.52
Total low,	-	182.07	78.34	92.87	10.86
Average per cow, high, . .	-	60.08	13.19	17.97	28.75
Average per cow, low, . .	-	30.34	13.06	15.48	1.81

Influence of Protein on Milk Yield.

Herd Results in Pounds.

CHARACTER OF RATION.	Average Weight of Cows.	Yield of Milk.	Daily Yield of Milk per Cow.	Protein digested.	Protein required for Maintenance and in Milk.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
High protein, . . .	899	3,261.0	25.82	360.49	186.97	173.52	92.8
Low protein, . . .	900	2,877.0	22.73	182.02	171.21	10.86	5.1

It will be seen that on the high-protein ration the cows received 92.8 per cent. more digestible crude protein than was required for maintenance and for the milk produced, while in low-protein ration the excess was only 5 per cent., the amount digested and the amount fed being substantially equal.

The figures show that for a period of twenty-one days, while not changing in weight, the herd produced 13.3 per cent. more milk on the high-protein diet, showing very distinctly the influence of the excess of protein. This experiment exactly confirms the experiment immediately preceding.

Composition of the Herd Milk (Per Cent.).

CHARACTER OF RATION.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Protein Equivalent.
High protein,	13.82	4.83	8.99	.526	3.28
Low protein,	14.10	5.02	9.08	.518	3.23

The samples were taken and averages secured in the same way as in the previous experiment. Here we have a direct reversal of the results, the low-protein ration showing a trifle higher average fat percentage than the high-protein ration. This may also be regarded as within the limit of error. The percentage of nitrogen in the milk produced during each half of the experiment is substantially the same, and this in spite of the fact that the low-protein ration contained but 1.45 pounds of digestible protein, and the high-protein ration 2.85 pounds.

Experiment III.¹

This experiment was one of a series designed to study the effect of food stuffs upon the composition of milk and of butter fat. Only that portion of the experiment is here published which shows the influence of protein upon the yield and composition of the milk. It was planned on the group system, five cows composing each group. The first two periods of the experiment only are needed in this connection.

Duration of Experiment.

PERIODS.	Dates of Experiment.	Length in Weeks.
First period: both herds standard ration, . .	Nov. 17, through Dec. 7, 1900,	3
Second period: { Herd I., standard ration, . Herd II., cottonseed ration, . }	Jan. 5, through Feb. 8, 1901,	5

¹ See résumé in fourteenth report of the Hatch Experiment Station, pp. 162-168.

Average Daily Rations (Pounds).

First period: both herds, standard grain ration.

HERDS.	Standard Grain Ration.	Cotton-seed Meal.	First-cut Hay.	Rowen.
Herd I.,	9	—	8-12	10
Herd II.,	9	—	8-12	10

Second period: Herd I., standard ration; Herd II., cottonseed ration.

Herd I.,	9	—	8-12	10
Herd II.,	5	3	8-12	10

The standard ration consisted of 3 pounds of wheat bran, 5 pounds of ground oats and 1½ pound each of cottonseed and gluten meals. The cottonseed meal contained some 9 per cent. of oil and 54.54 per cent. of protein in dry matter.

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

First period: both herds, standard grain ration.

HERDS.	Dry Matter.	Protein.	Fiber and Extract Matter.	Fat.	Total.	Nutritive Ratio.
Herd I.,	26.15	2.44	12.84	.68	15.95	1:5.8
Herd II.,	26.97	2.49	13.25	.69	16.42	1:5.9

Second period: Herd I., standard grain ration; Herd II., cottonseed ration.

Herd I.,	25.00	2.34	12.27	.66	15.27	1:5.8
Herd II.,	25.69	3.20	11.62	.73	15.55	1:4.1

The digestibility of the standard grain mixture was ascertained by actual experiment. Average coefficients were used for the other feeds. Both herds received substantially the same amounts of protein and total digestible nutrients in the first period. Each herd averaged in live weight about 950 pounds. In the first period the amount of digestible protein was ample to enable the cows to do good work. In the second period Herd II. received .86 of a pound more of digestible protein than did Herd I.

Total and Average Daily Yield of Milk (Pounds).

First period: both herds, standard grain ration.

HERDS.	Total Herd Yield.	Average Daily Yield.
Herd I.,	2,332.5	22.2
Herd II.,	2,405.3	22.9

Second period: Herd I., standard ration; Herd II., cottonseed meal ration.

Herd I.,	3,856.3	21.9
Herd II.,	3,898.1	22.2

In the first period Herd II. produced 3.1 per cent. more milk than Herd I., and in the second period 1 per cent. more. It would appear, therefore, that the amount of protein fed in the first period was ample, and that the increase given to Herd II. in the second period was not needed and did not increase the milk flow. In the first period Herd I. gained 6 pounds in live weight, and Herd II., 83 pounds. In the second period Herd I. lost 87 pounds, and Herd. II., 73 pounds.

Average Composition of the Herd Milk (Per Cent.).

First period: both herds, standard grain ration.

HERDS.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Protein Equivalent.	Ash.
Herd I.,	14.15	5.00	9.15	.538	3.36	.73
Herd II.,	14.27	4.93	9.34	.546	3.41	.72

Second period: Herd I., standard ration; Herd II., cottonseed meal ration.

Herd I.,	14.16	5.06	9.10	.550	3.44	.73
Herd II.,	14.30	4.98	9.32	.562	3.51	.71

The analyses for the first period represent the average of 3 separate samples, each covering a period of five days; those for the second period represent the average of 5 separate samples, each covering a period of five days. Each five-day composite represented the average composition of the herd milk for one week. The separate analysis of each cow's milk was not made.

In the first period the milk of the two herds showed itself to be practically identical in composition. In the second period the substitution of 3 pounds of cottonseed meal for 4 pounds of the standard ration, thereby increasing the digestible protein in the ration .86 of a pound, had no effect whatever in varying the proportions of the milk. It is well to remember in this connection that nearly a month intervened between the first and second periods ¹, and that the period itself covered five weeks. It is possible that, if the standard ration had contained a pound less of digestible protein daily, some difference may have been observed in the composition of the milk produced by the two herds in the second period.

Influence of Protein on the Milk Yield (Pounds).

Herd Results, Second Period.

CHARACTER OF RATION.	Average Weight of Cow.	Total Yield of Milk.	Protein digested.	Protein required for Maintenance.	Protein in Milk.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
Standard,	946	3,856.3	409.5	115.5	132.6	161.4	65.0
Cottonseed meal, .	939	3,898.1	560.0	115.5	136.8	307.7	122.0

In so far as this experiment throws any light on the protein requirements, it indicates that Herd I. was receiving ample protein (65 per cent. above the minimum requirement), and that the addition of more protein (122 per cent. above the minimum) was without any noticeable influence upon the milk yield.

Experiment IV.

This experiment was completed during the winter of 1897-98, although the results have not been published. It was conducted on the reversal method, with twelve mature grade Jersey cows, all of which had freshened the previous summer and autumn.

Weighing Animals. — Each animal was weighed for three

¹ This excessive lapse of time was due to some of the cows not being in best of condition.

consecutive days, before feeding in the afternoon, at the beginning and end of each half of the experiment.

Weighing and Sampling the Milk. — The weight of each milking was taken on a spring balance sensitive to 1 ounce, and the weights preserved on prepared record sheets. The milk was sampled for five consecutive days by the usual method, as described in accounts of the many feeding experiments given in previous reports. It was preserved with bichromate of potash and analyzed by gravimetric methods.

Character of Feeds. — The feeds used were all of good quality and of average composition. The hay was composed largely of Kentucky blue grass, sweet vernal grass and a liberal admixture of clover.

Dates of the Experiment.

First Half.

DATES.	Weeks.	High-protein Cows.	Low-protein Cows.
Nov. 13, 1897 to Jan. 14, 1898,	9	Guernsey, Midget, Susie, Beauty, Sadie, Alice.	Bessie, Mary, Mildred, Nina, Blossom, Jennie.

Second Half.

Jan. 24 to March 27, 1898, .	9	Bessie, Mary, Mildred, Nina, Blossom, Jennie.	Guernsey, Midget, Susie, Beauty, Sadie, Alice.
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It will be observed that ten days were allowed for changing the feeds given the animals.

Average Daily Rations fed to Each Cow (Pounds).

CHARACTER OF RATION.	Wheat Bran.	Gluten Feed.	Corn Meal.	English Hay.	Corn Silage.
High protein,	3	5.5	—	10.9	25.7
Low protein,	3	1.5	4	11.0	25.7

It will be seen that the two rations were practically identical, excepting that 4 pounds of corn meal were substituted for a like amount of gluten feed. Different cows received from 10 to 12 pounds of hay and from 20 to 30 pounds of silage. Each animal received exactly the same amount of grain daily.

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

CHARACTER OF RATION.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.				Nutritive Ratio.
		Protein.	Carbo-hydrates.	Fat.	Total Nutrients.	
High protein,	24.17	2.10	13.00	.50	15.60	1:6.7
Low protein,	24.24	1.67	13.70	.53	15.90	1:8.9

The herd averaged about 900 pounds in weight. The amount of dry matter and of total digestible nutrients fed in each ration was substantially the same; the high-protein ration contained about .4 of a pound more digestible protein than the low-protein ration. The excess over the low-protein ration is not marked and is very much less than that fed in experiments I. and II., previously mentioned.

Herd Gain in Live Weight (Pounds).

CHARACTER OF RATION.	Gain or Loss.
High protein,	+353
Low protein,	+223

Both rations caused a gain in weight, the excess being in favor of the high-protein ration. This may have been expected, as the low-protein ration had rather too wide a ratio to be productive of the best results.

Protein Balance (Pounds).

Herd Results; Periods of Sixty-three Days.

CHARACTER OF RATION.	Protein digested.	Protein required for Maintenance.	Protein contained in Milk (N. x 6.25).	Protein Excess over Maintenance and Milk Requirements.
High protein,	1,587.6	476.28	591.76	519.6
Low protein,	1,262.5	476.28	563.23	223.0

Influence of Protein on Milk Yield.

Herd Results in Pounds.

CHARACTER OF RATION.	Average Weight of Cow.	Yield of Milk.	Daily Yield of Milk Per Cow.	Protein digested.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
High protein, . . .	900	16,257	21.5	1,587.6	519.6	48.6
Low protein, . . .	900	15,347	20.3	1,262.5	223.0	21.4

The average amount of digestible protein fed daily per cow in the high-protein ration — 2.10 pounds — could not be considered excessive, although it was 48.6 per cent. more than was required for milk and maintenance. The average amount of digestible protein fed daily per cow in the low-protein ration was 1.67 pounds, which was 21.4 per cent. above that necessary for milk and maintenance. The high-protein ration, being 48.6 per cent. in excess of the protein minimum, produced 5.9 per cent. more milk than did a ration made up of similar feedstuffs which was 21.4 per cent. in excess of the minimum. Such a difference in an experiment extending over a period of sixty-three days is believed to be too pronounced to be attributed to an experimental error, and is evidently the result of the increased amount of protein fed. In this connection it may be remarked that if the practical feeder purchased all of his grain, it would be to his advantage to buy gluten feed rather than corn meal. If he produces his own corn, the feeding of one-third bran, one-half corn and cob meal and one-sixth gluten feed would be advisable.

Composition of the Herd Milk (Per Cent.).

CHARACTER OF RATION.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Protein Equivalent (N. x 6.25).	Ash.
High protein, . . .	14.55	5.11	9.44	.58	3.64	.75
Low protein, . . .	14.44	5.01	9.43	.59	3.67	.74

Samples of milk from each cow were taken weekly for five consecutive days, and tested for total solids and for fat. The average percentage produced by each cow for the nine weeks was multiplied by the amount of milk produced during the same period, and the amounts of total solids and of fat produced by the entire herd on each of the two rations calculated. These amounts, divided by the total milk yield, gave the average percentages of total solids and fat produced by each herd for the entire period.

The product of each milking of the six cows receiving the two different rations was also mixed, and composite five-day samples tested for total solids, fat, nitrogen and ash. In case of total solids and fat the average results varied less than .1 per cent. from those secured by the other method. The average results stated in the table above represent those secured by the last-described method.

It will be seen that the two rations produced milk of substantially the same composition. While the excess of protein appeared to have noticeably influenced the amount of the milk produced, it was without influence on its composition.

Experiment V. — 1898.

This experiment was conducted on the same plan as experiment IV., and the conditions were substantially the same. Nine cows only were used, being divided into herds of five and four.

Dates of the Experiment.

First Half.

DATES.	Days.	High-protein Cows.	Low-protein Cows.
April 4 to April 29, 1898, .	26	Blossom, Jennie, Bessie, Mary, Mildred.	Beauty, Alice, Guernsey, Midget.

Second Half.

May 8 to June 2, 1898, .	26	Beauty, Alice, Guernsey, Midget.	Blossom, Jennie, Bessie, Mary, Mildred.
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Nine days elapsed between halves, and the halves themselves lasted twenty-six days each. The "cow balance" was hardly

satisfactory in this experiment, five cows receiving one ration at the same time four were receiving the other, and *vice versa*. These were the only animals at the time that were in suitable condition.

Average Daily Rations fed to the Nine Cows (Pounds).

CHARACTER OF RATION.	Wheat Bran.	Gluten Feed.	Corn Meal.	English Hay.	Rowen.
High protein,	3	5	—	9.3	9.3
Low protein,	3	1	4	9.3	9.4

These two rations differ only in that 4 pounds of corn meal took the place of a like amount of gluten feed.

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

CHARACTER OF RATION.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.				Nutritive Ratio.
		Protein.	Carbo-hydrates.	Fat.	Total Nutrients.	
High protein,	23.62	2.41	11.97	.43	14.81	1:5.4
Low protein,	23.44	1.96	12.39	.44	14.79	1:6.8

In the so-called low-protein ration the herd received substantially 2 pounds of digestible protein daily; in the high-protein ration this was increased .4 of a pound. The total digestible nutrients fed were the same in each case. The cows averaged 970 to 960 pounds in live weight during the two halves of the experiment. In the low-protein ration the amount of protein fed was sufficient to give satisfactory results.

Herd Gain in Live Weight (Pounds).

CHARACTER OF RATION.	Gain or Loss.
High protein,	+76
Low protein,	+115

Protein Balance (Pounds).

Herd Results; Periods of Twenty-six Days.

CHARACTER OF RATION.	Protein digested.	Protein required for Main- tenance.	Protein contained in Milk.	Protein Excess over Main- tenance and Milk Require- ments.
High protein,	563.9	156.8	184.4	222.7
Low protein,	458.6	155.5	174.8	128.3

Influence of Protein on Milk Yield.

Herd Results in Pounds.

CHARACTER OF RATION.	Average Weight of Cow.	Yield of Milk.	Daily Yield of Milk Per Cow.	Protein digested.	Protein Excess over that required for Main- tenance and Milk.	Per- centage Excess.
High protein,	960	4,693.5	20.06	563.9	222.7	65.3
Low protein,	950	4,370.6	18.68	458.6	128.3	39.0

The average amount of digestible protein fed daily to each cow in the high-protein ration was 2.41 pounds, and the excess over that required for milk and maintenance was 65.3 per cent. In the low-protein ration each cow received 1.96 pounds daily, and an average excess of 39 per cent. above requirements.

During the high-protein feeding the herd produced 7.4 per cent. more milk than when it received the low-protein ration, showing the influence of the larger amount. Whether all of the milk increase was due to the extra protein consumed is uncertain. The low-protein ration naturally had a wider ratio, and evidently was rather better suited to fattening than to milk production, and was indicated by the increase in live weight.

Composition of the Herd Milk (Per Cent.).

CHARACTER OF RATION.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Protein EQUIVA- lent (N x 6.25).	Ash.
High protein,	14.83	5.00	9.84	.63	3.93	.74
Low protein,	14.90	5.07	9.82	.66	4.00	.76

The above figures represent the average of five-day composite samples of the milk produced by the herd of nine cows while on the two different rations. Samples of *each cow's* milk were also tested five days in each week for total solids and fat. The average of the two herds by this method varied less than .1 per cent. from the above figures. It is, therefore, evident that the difference in the amount of protein in the ration did not vary the fat, solids not fat, nitrogen or ash content of the milk.

Experiment VI. — 1905-06.

This experiment, hitherto not reported, was carried out by the group method, six cows constituting each of two groups.

The object of the experiment was to note the effect of a ration low in digestible protein, — the amount required in the milk plus that for maintenance, — as compared with one containing approximately $\frac{1}{2}$ pound in excess. The effect of the two rations was to be noted (*a*) on the condition of the animals; (*b*) on the yield of milk, milk solids, fat and nitrogen; (*c*) on the relative shrinkage; (*d*) on the composition of the milk.

Plan of the Experiment. — The twelve cows were divided as evenly as possible into two groups. The first few weeks both groups received the low-protein ration in order to establish a basis for comparison. The record of the milk yield and its composition is reported for the last week of this preliminary period. At the beginning of the period proper, Group II. received the high-protein ration, and Group I. continued on that low in protein.

History of the Cows.

NAME.	Breed.	Age (Years).	Last Calf dropped.	Days with Calf, Beginning of Test.
Blanche,	Grade Guernsey, .	10	October, 1905	57
Daisy,	Grade Jersey, .	7	August, 1905	79
Fancy,	Grade Jersey, .	6	August, 1905	79
Gladys,	Pure Jersey, .	3	December, 1905	-
Maude,	Grade Guernsey, .	2	December, 1905	18
May,	Grade Jersey, .	10	July, 1905	63
Betty,	Grade Jersey, .	2	November, 1905	-
Dora,	Grade Jersey, .	12	August, 1905	-
May Rio,	Pure Jersey, .	3	October, 1905	64
Molly,	Grade Jersey, .	10	July, 1905	-
Red II.,	Grade Jersey, .	10	November, 1905	20
Samantha,	Grade Jersey, .	3	August, 1905	51

Weighing Cows. — Each cow was weighed for three consecutive days at the beginning and end of the period proper, before watering and feeding in the afternoon. These weights were also taken twice during the intervening time.

Sampling Feeds. — Samples of hay and silage were taken at the beginning of the period, and every two weeks thereafter. In case of the hay, forkfuls were taken here and there from the entire amount to be fed for the day, run through a feed cutter, subsampled, the final sample brought to the laboratory in glass-stoppered bottles, dry-matter determinations made at once and the sample saved for a composite. The silage was similarly sampled, excepting that it was not run through the cutter. The grain was sampled daily, preserved in glass-stoppered bottles, and at the end of the period analyzed.

Sampling Milk. — The milk of each cow was sampled for five consecutive days in each week by the usual method, and the composite tested for fat, total solids, nitrogen and ash.

Dates of the Experiment.

Preliminary Period.

HERD.	Character of Ration.	Dates.	Weeks.	Cows.
I., . . .	Low protein, .	January 27 through February 2.	1	Blanche, Daisy, Fancy, Gladys, Maude, May.
II., . . .	High protein, .	January 27 through February 2.	1	Betty, Dora, May Rio, Molly, Red II., Samantha.

Period Proper.

I., . . .	Low protein, .	February 10 through April 27.	11	Blanche, Daisy, Fancy, Gladys, Maude, May.
II., . . .	High protein, .	February 10 through April 27.	11	Betty, Dora, May Rio, Molly, Red II., Samantha.

Average Daily Rations consumed by the Two Herds (Pounds).

Preliminary Period.

HERD.	Character of Ration.	English Hay.	Corn Silage.	Wheat Bran.	Corn Meal.	Gluten Meal.
I.,	Low protein, .	12.6	22.5	3.4	3.3	-
II.,	Low protein, .	12.6	22.2	3.4	3.3	-

Period Proper.

I.,	Low protein, .	12.6	22.2	3.4	3.3	-
II.,	High protein, .	13.0	21.0	3.7	1.2	2.2

The amount of hay fed to the different cows varied from 11 to 15 pounds; silage, from 20 to 30 pounds; bran, from 3 to 4.5 pounds; corn meal, from 3 to 4.5 pounds, and gluten meal, from 2 to 3 pounds daily.

Average Amounts of Dry and Digestible Matter consumed by Each Cow daily (Pounds).

Preliminary Period.

HERD.	Character of Ration.	Dry Matter.	Protein.	Fiber.	Extract Matter.	Fat.	Total.	Nutritive Ratio.
I., . . .	Low protein, .	21.75	1.22	3.58	8.39	.42	13.61	1:10.6
II., . . .	Low protein, .	22.51	1.27	3.63	8.68	.43	14.02	1:10.4

Period Proper.

I., . . .	Low protein, .	21.70	1.22	3.58	8.37	.41	13.58	1:10.5
II., . . .	High protein, .	22.18	1.76	3.60	8.14	.41	13.91	1: 7.2

Herd I. averaged 912 pounds and Herd II. 903 pounds in live weight. On the basis of 1,000 pounds live weight, Herd I. would be receiving 1.34 pounds of digestible protein and 14.9 pounds total digestible matter, and Herd II., 1.95 pounds digestible protein and 15.4 pounds of total digestible matter daily in the period proper. The digestible matter was calculated from actual analyses of the feeds, and average digestion coefficients. It seems probable that the results are a trifle low, and that more material was actually digested than the calculations show, for the animals appeared well nourished, Herd I. gaining 225 pounds, and Herd II., 215 pounds during the eleven weeks of the period proper. The low-protein ration was evidently somewhat deficient in protein and too wide. The high-protein ration must have satisfied the protein requirements, and on the basis of 1,000 pounds live weight, it contained .6 of a pound more of digestible protein daily than did the other ration.

Weight of Animals at Beginning and End of Experiment (Pounds).

HERD.	Period.	Blanche.	Daisy.	Fancy.	Gladys.	Maude.	May.	Betty.	Dora.	May Rio.	Molly.	Red II.	Samantha.	Gain or Loss.
I., .	Beginning, .	1,167	837	835	732	778	1,010	-	-	-	-	-	-	-
	End, .	1,230	892	865	707	813	1,077	-	-	-	-	-	-	+225
II., .	Beginning, .	-	-	-	-	-	-	672	843	758	1,018	1,007	1,013	-
	End, .	-	-	-	-	-	-	712	877	808	1,088	1,063	978	+215

Judging from the above weights it would appear that both herds were well nourished and able to add slightly to their live weight.

Crude Protein Balance (Pounds).

Preliminary Period: One Week.

CHARACTER OF RATION.	Protein digested.	Protein for Maintenance.	Protein for Milk.	Protein Deficit.	Percentage Deficit.
Low protein, Herd I., . .	51.3	30.4	27.18	-6.28	-11.0
High protein, Herd II., . .	53.3	30.4	28.66	-5.76	-9.7

Crude Protein Balance (Pounds).

Period Proper, Eleven Weeks.

HERD.	Character of Ration.	Cows.	Protein digested.	Protein required for Maintenance.	Protein required in Milk (N. x $\frac{1}{25}$).	Excess over Maintenance and Milk Requirements.	Percentage Excess.
II., .	High protein,	Betty, . .	118.58	37.30	45.87	35.41	42.6
		Dora, . .	124.74	46.35	53.55	24.84	24.9
		May Rio, .	128.59	42.20	49.82	36.57	39.7
		Molly, . .	133.21	56.76	52.48	23.97	21.1
		Red II., .	174.02	55.79	70.01	48.22	38.3
		Samantha, .	133.21	53.68	56.54	22.99	20.9
I., .	Low protein,	Blanche, .	104.72	64.68	43.55	-4.51	-4.2
		Daisy, . .	99.79	46.62	44.20	6.97	7.7
		Fancy, . .	92.40	45.82	49.49	-2.91	-3.1
		Gladys, .	93.90	38.81	50.88	4.21	4.7
		Maude, . .	77.77	42.85	34.98	-.06	±
		May, . .	96.25	56.27	49.49	-9.51	-9.0

Influence of Protein on Milk Production (Pounds).

Preliminary period: both herds, low-protein ration.

RATION.	Average Weight of Cow.	Digestible Protein consumed daily per Cow.	Percentage Deficit or Excess Protein over Requirements.	Total Milk Yield.	Average Daily Yield.	Yield of Solids.	Yield of Fat.	Yield of Protein (N. x 6.25).
Low,	-	1.22	-11.0	747.8	17.80	108.95	37.97	27.18
Low,	-	1.27	-9.7	821.3	19.55	115.66	40.67	28.66
Percentage excess, Herd IV. over Herd I.	-	-	-	9.8	-	6.20	7.00	5.50

Period proper: Herd I., low protein; Herd II., high protein.

Low,	912	1.22	±	7,415.6	16.05	1,102.10	398.90	272.60
High,	903	1.76	31.3	8,906.5	19.28	1,294.80	473.00	328.30
Percentage increase, high over low.	-	-	-	20.1	-	17.50	18.60	20.00

It was hardly possible, with the cows at our disposal, to select two herds of six each that would produce substantially equal amounts of milk. It will be seen, therefore, that Herd II. in the preliminary period was producing nearly 10 per cent. more milk and from 5.5 to 7 per cent. more protein and fat than Herd I.

In the second or period proper, covering eleven weeks, this percentage was increased from 9.8 to 20 in case of the milk; substantially similar increases were also noted in case of the milk ingredients. Otherwise expressed, Herd II., receiving the high-protein ration, nearly maintained its flow during the second period, while each cow in Herd I. showed an average daily decrease of 1.75 pounds, or practically 10 per cent.

In the preliminary period both herds were receiving from 10 to 11 per cent. less protein than was actually needed for maintenance and milk. In the second period the low-protein herd had approximately reached a balance between income and outgo, while the high-protein herd was receiving 31.3 per cent. of crude protein in excess of requirements. The effect

of this extra protein may be clearly seen in maintaining the flow of milk. It would be of interest to know whether it would have maintained its influence throughout the entire milking period. The herd receiving the shortage of protein was obliged to adjust itself to the low-protein diet. It was able to increase somewhat in live weight (fat?), but its milk flow was of necessity noticeably checked. It is quite probable that some cows of pronounced ability as milkers would not shrink as rapidly as others on a low-protein diet, but for a time would have taken the needed protein from that stored in the body.

Effect of Protein on Average Composition of the Milk (Per Cent.).

HERDS.	Period.	Character of Ration.	Total Solids.	Fat.	Solids not Fat.	Protein.
I.,	I.,	Low protein, .	14.57	5.08	9.49	3.63
I.,	II.,	Low protein, .	14.86	5.38	9.48	3.69
Increase, . .	—	—	.29	.30	±	.06
II.,	I.,	Low protein, .	14.08	4.95	9.13	3.49
II.,	II.,	High protein, .	14.54	5.31	9.23	3.69
Increase, . .	—	—	.46	.36	.10	.20

The above average figures were secured by taking the average of the weekly analysis of the milk produced by each cow and multiplying it by the pounds of milk produced, the result being the pounds of the several ingredients produced by each cow. These were added, and gave the total milk and milk ingredients produced by each herd. The total ingredients divided by the total milk produced gave the average percentages. The fact that the milk produced by each herd did not show the same composition in the preliminary period prevents a direct comparison. It will be observed, however, that in case of Herd I. the milk in the second period changed but little in composition from that produced in the first period, the principal difference being a slight increase in the fat, due evidently to the advance in lactation. Herd II. produced milk also with only slight variations in the two periods. The fat increased .36 of 1

per cent., being about the same increase as with Herd I. The protein showed rather more of an increase than in case of Herd I., and this may possibly be attributed to the influence of the extra protein in the food. It must be remembered that Herd I. received a ration deficient in protein, and the increased amount given to Herd II. may have had a slight effect upon the milk protein. With this exception it is safe to state that the protein was entirely without influence upon the composition of the milk.

Experiment VII. — 1907-08.

This experiment was conducted with six cows, the only ones available at the time, and was by the group method.

The object of the experiment was primarily to note the effect of rations low and high in protein (a) upon the condition of the animals, (b) upon the yield of milk, and (c) upon the relative milk shrinkage.

The plan of the experiment consisted in dividing six cows into two herds of three each, which were known as Herds D and E. The first ten days were regarded as preliminary, to accustom the two herds to their distinct rations. Herd D received the low-protein ration and Herd E the one high in protein.

Weighing Cows. — Each of the cows was weighed for three consecutive days at the beginning and end of the experiment, and every fourth week during its progress. They were weighed in the afternoon before being fed or watered.

Sampling Feeds. — The hay was sampled in the usual way at the beginning of the experiment, and every two weeks thereafter. The grain was sampled daily and preserved in glass-stoppered bottles, and eventually tested for dry matter and for the ordinary ingredients.

Character of Feeds. — The hay was a mixture of grasses, the finer varieties, such as Kentucky blue grass, predominating. It contained a noticeable admixture of clover.

Sampling Milk. — The cows were milked twice daily, and the single milking of each cow in each herd was poured into a common receptacle, mixed and the herd mixture sampled. This method was continued for five consecutive days, each single

sample composited, and eventually tested for solids, fat and nitrogen. It will therefore be seen that herd samples only were analyzed, and not the product of individual cows.

History of Cows.

HERD.	Cows.	Breed.	Age (Years).	Last Calf dropped.	Days with Calf at Begin- ning of Trial.
D,	Samantha, .	Jersey-Holstein, .	4	September 3	8
	May Rio, .	Pure Jersey, .	4	September 12	-
	Daisy, . .	Grade Jersey, .	8	August 23	-
E,	Fancy, .	Grade Jersey, .	7	September 1	-
	Gladys, .	Pure Jersey, .	4	October 7	-
	Red III., .	Grade Jersey, .	2	October 27	-

Duration of the Experiment.

HERD.	Character of Ration.	Dates.	Number of Weeks.	Cows.
D,	Low protein, .	Nov. 23, 1907, through May 8, 1908.	24	Samantha, May Rio, Daisy.
E,	High protein, .	Nov. 23, 1907, through May 8, 1908.	24	Fancy, Gladys, Red III.

Rations consumed daily by Each Cow (Pounds).

HERD.	Character of Ration.	Cows.	Hay.	Wheat Bran.	Corn Meal.	Gluten Feed.
D,	Low protein, .	Samantha, .	22	3.40	4.50	-
		May Rio, .	20	3.00	4.00	-
		Daisy, . .	20	3.00	4.00	-
E,	High protein, .	Gladys, . .	20	3.00	-	3.90
		Fancy, . .	22	3.40	-	4.60
		Red III., .	16	2.50	-	3.40
Average, Herd D,	-	-	20.7	3.13	4.16	-
Average, Herd E,	-	-	19.3	2.97	-	3.97

The difference in the two rations consisted in the substitution of corn meal for gluten feed. The latter, as is well known,

is a by-product of the former, hence the general character of the two variables was the same, and particularly the protein.

Digestible Matter in Daily Rations (Pounds).

HERD.	Character of Ration.	Cows.	DIGESTIBLE NUTRIENTS.				Nutritive Ratio.
			Protein.	Fat.	Carbohy- drates.	Total.	
D, . .	Low protein, .	Samantha, .	1.44	.48	14.27	16.19	1:10.7
		May Rio, .	1.29	.43	12.87	14.59	1:10.6
		Daisy, . .	1.29	.43	12.87	14.59	1:10.6
E, . .	High protein, .	Gladys, . .	1.88	.38	12.23	14.49	1:6.9
		Fancy, . .	2.14	.43	13.65	16.22	1:6.8
		Red III., .	1.58	.31	9.97	11.86	1:6.6
Average, Herd D,	-	-	1.34	.45	13.34	15.12	1:10.6
Average, Herd E,	-	-	1.87	.37	11.95	14.19	1:6.7

The above figures were secured from the actual analyses of the feeds and average digestive coefficients. It is clear that Herd D received a ration with a very wide nutritive ratio, while Herd E received a ration with a medium ratio.

Average Weight of Cows at Beginning and End of Period (Pounds).

	HERD D.			HERD E.		
	Daisy.	May Rio.	Samantha.	Fancy.	Gladys.	Red III.
Beginning, . . .	920	898	1,003	973	810	680
End, . . .	923	907	1,063	1,013	818	782
Total gain, Herd D, 69 pounds.				Total gain, Herd E, 150 pounds.		

Herd E made a larger gain than Herd D, but this appears to be due largely to the gain made by Red III., a heifer with first calf.

Crude Protein Balance (Pounds).

HERD.	Character of Ration.	Average Weight.	Protein digested (N. x 6.25).	(Protein required for Maintenance (N. x 6.25).)	Protein required for Milk (N. x 6.25).	Protein Excess or Deficit.	Percentage Excess or Deficit.
D, . .	Low protein,	935	675.36	328.00	351.50	-4.14	-.6
E, . .	High protein,	832	942.48	291.75	389.37	261.36	38.4

The total protein digested was calculated from the amount digested daily multiplied by the number of days of the experiment. The protein for maintenance was calculated from the average weight of each herd, allowing .7 of a pound of digestible protein per 1,000 pounds live weight. The protein in the milk was calculated from the actual analysis of the milk. It is admitted that the above results are only approximate, being secured partly from average figures, and on the basis of crude in place of true protein. They indicate, however, that Herd D was receiving a ration rather deficient in protein, and that Herd E was receiving at least 38.4 per cent. over that required for maintenance and milk.

Milk Yield and Milk Shrinkage.

HERD.	Character of Ration.	MILK PRODUCED AND SHRINKAGE.			
		Total Yield (Pounds).	First Week (Pounds).	Last Week (Pounds).	Per Cent. Shrinkage.
D,	Low protein, .	9,287.1	446.3	368.8	17.4
E,	High protein, .	11,161.5	514.5	401.6	21.9

In spite of the fact that the three cows comprising Herd D received hardly sufficient protein for maintenance and milk produced, they did not shrink as much during a period of twenty-four weeks as did the three cows in Herd E, which received substantially 38 per cent. protein in excess of supposed requirements. Such a result can only be explained on the ground that the animals were too few in number to give accurate results by the group method, and that individuality rather than food appeared to be the controlling factor. See also Experiment VIII.

Experiment VIII. — 1908-09.

This experiment was planned primarily to study the protein requirements of dairy animals. It will not show the effect of protein upon the chemical composition of the milk.

Plan of the Experiment. — Inasmuch as the cows in the herd calved at different times, the experiment was planned with pairs of cows, *i.e.*, each pair of cows, when ready, was started,

one on a diet approximately sufficient to furnish protein for maintenance plus that contained in the milk, and the other on a diet containing some $\frac{1}{2}$ pound more protein daily than the maintenance and milk requirements.

Duration of the Experiment. — The experiment was planned to continue substantially through a milking period, or until the animals were so far advanced in lactation as to cease to respond to the influence of food.

Weighing the Cows. — Each animal was weighed for three consecutive days at the beginning of the period, and for three days each two weeks thereafter.

Sampling Feeds. — The hay fed was sampled at the beginning of the period for each pair of cows, and each two weeks thereafter. The samples were placed in glass-stoppered bottles, taken to the laboratory and dry-matter determinations made at once. The method of sampling has been described in preceding experiments.

Each kind of grain was sampled daily during the process of weighing out, and the composite samples preserved in glass-stoppered bottles. Dry-matter determinations were made once each month, and the monthly samples composited.

Character of Feeds. — It was intended to procure one lot of hay of the same quality sufficient to last during the entire experiment. Owing to several unfortunate circumstances this was not possible. Three different lots were secured, and composite samples of each analyzed. The digestibility was not determined, but approximate coefficients applied, depending upon the analysis and general appearance of the hay. The several grains were procured in large amounts and average digestion coefficient applied.

Sampling Milk. — The milk of each cow was sampled for five consecutive days at the beginning of the period, and each two weeks thereafter. It was tested for total solids, for fat by the Babcock method in duplicate, and for nitrogen by the Kjeldahl method.

History of the Cows.

PAIRS.	Cows.	Breed.	Age (Years).	Last Calf dropped.	Daily Yield at Beginning of Ex- periment. Pounds.
I., . . .	Minnie, .	Grade Holstein, .	8	September 12,	26.0
	Mary, . .	Grade Holstein, .	10	September 5,	26.0
II., . . .	Samantha, .	Jersey-Holstein, .	6	August 27,	26.0
	Chub, . .	Grade Holstein, .	10	September 1,	20.0
III., . . .	Betty, . .	High-grade Jersey,	4	September 25,	26.3
	May Rio, .	Pure Jersey, . .	6	October 13,	27.5
IV., . . .	Daisy, . .	High-grade Jersey,	11	October 22,	28.7
	Cecile, . .	Pure Jersey, . .	4	October 10,	25.7
V., . . .	Red III., .	High-grade Jersey,	2	October 30,	29.0
	Betty II., .	High-grade Jersey,	2	-	-

Duration of Experiment.

Cows.	Preliminary Period began.	Period Proper.	Number of Days.
Minnie,	October 10,	October 17 through April 30,	196
Mary,	October 10,	October 17 through April 30,	196
Samantha,	October 10,	October 17 through May 28,	224
Chub,	October 10,	October 17 through May 28,	224
Betty,	October 24,	November 14 through June 11,	210
May Rio,	October 24,	November 14 through June 11,	210
Daisy,	October 31,	November 14 through May 28,	196
Cecile,	October 31,	November 14 through May 28,	196
Red III.,	November 28,	December 12 through June 11,	182
Betty II.,	December 17,	December 26 through June 11,	168

Rations consumed daily by Each Cow (Pounds).

CHARACTER OF RATION.	Number of Days.	Cows.	Hay.	Wheat Bran.	Corn Meal.	Gluten Feed.
High protein, . . .	196	Mary, . .	21.4	3.0	-	3.93
	224	Chub, . .	17.6	3.0	-	3.51
	210	Betty, . .	19.4	3.0	.80	3.87
	196	Cecile, . .	17.0	3.0	.43	3.48
	168	Betty II., .	16.4	3.0	1.00	3.00
Low protein, . . .	196	Minnie, . .	20.0	3.0	3.51	.51
	224	Samantha, .	22.0	3.9	3.90	-
	210	May Rio, . .	19.6	3.0	4.80	-
	196	Daisy, . .	19.3	3.0	4.00	.44
	182	Red III., .	19.5	3.0	4.00	.41
Average, high protein, .	-	-	18.4	3.0	.74	3.56
Average, low protein, .	-	-	20.1	3.2	4.10	.45

The substantial difference in the rations of the two lots of cows consisted in the fact that the high-protein cows received the gluten feed and the low-protein cows the corn meal.

Dry and Digestible Matter in Daily Rations (Pounds).

CHARACTER OF RATION.	Cows.	Dry Matter.	DIGESTIBLE.				Nutritive Ratio.
			Protein.	Fat.	Carbohy- drates.	Total.	
High protein, . . .	Mary, . .	25.1	2.05	.55	12.26	14.86	1:6.57
	Chub, . .	21.3	1.79	.38	10.41	12.58	1:6.28
	Betty, . .	23.9	1.95	.43	12.04	14.42	1:6.66
	Cecile, . .	21.1	1.74	.38	11.06	13.18	1:6.84
	Betty II., .	20.7	1.61	.38	10.32	12.31	1:6.93
Low protein, . . .	Minnie, . .	23.8	1.47	.42	12.23	14.12	1:8.95
	Samantha, .	26.0	1.44	.43	12.90	14.77	1:9.62
	May Rio, . .	24.2	1.36	.44	12.70	14.50	1:10.51
	Daisy, . .	22.7	1.34	.39	11.61	13.34	1:9.30
	Red III., .	23.7	1.36	.41	12.63	14.40	1:9.95
Average, high protein,	-	22.4	1.83	.42	11.22	13.47	1:6.65
Average, low protein,	-	24.1	1.39	.42	12.41	14.27	1:9.61

It will be seen that the cows receiving the larger amount of protein did not receive by .8 of a pound as much total digesti-

ble matter as the low-protein cows. The amount of food fed daily to each cow was gauged partly by the appetite of the animal. The high-protein cows received only .44 of a pound more digestible protein than the other herd.

Influence of Rations on Weight (Pounds).

CHARACTER OF RATION.	Cows.	Average Weight.	Weight at Beginning.	Weight at End.	Total Gain or Loss.
High protein, . . .	Mary, . . .	1,074	1,047	1,102	+55
	Chub, . . .	1,011	955	1,067	+112
	Betty, . . .	869	843	895	+52
	Cecile, . . .	805	783	827	+44
	Betty II., . .	743	742	745	+03
Low protein, . . .	Minnie, . . .	971	923	1,018	+95
	Samantha, . .	1,068	995	1,142	+147
	May Rio, . . .	826	825	827	+02
	Daisy, . . .	830	798	862	+64
	Red III., . .	837	807	867	+60
Herd average, high, . . .	-	900	874	927	+266
Herd average, low, . . .	-	906	869	943	+368

The cows receiving the low-protein ration gained rather more in weight than the other herd; whether this was due to the character of the ration, or whether it simply depended upon the individuality of the animal, it is difficult to say.

True¹ Protein Balance (Pounds).

CHARACTER OF RATION.	Cows.	True Protein digested.	Protein required for Maintenance.	Protein found in Milk. (N. x 6.25).	Excess over Maintenance and Milk Requirements.	Percentage Excess.
High protein, . . .	Mary, . . .	350.97	147.35	143.10	60.52	20.8
	Chub, . . .	368.24	158.52	124.71	85.01	30.0
	Betty, . . .	380.61	127.74	156.35	96.52	34.0
	Cecile, . . .	316.38	110.45	136.07	69.86	28.3
	Betty II., . .	256.82	87.37	114.69	54.75	27.1
Low protein, . . .	Minnie, . . .	277.15	133.22	143.73	00.20	+
	Samantha, . .	320.40	167.46	168.14	-15.20	-4.5
	May Rio, . . .	284.48	121.42	136.07	20.99	10.5
	Daisy, . . .	259.20	113.87	140.52	4.80	1.9
	Red III., . .	247.13	106.63	119.58	20.92	9.2

The high-protein cows received an average of 28 per cent. of protein over maintenance and milk requirements, while in case of the low-protein cows the percentage varied from an actual shortage of 4.5 per cent. to a surplus of 10.5 per cent.

¹ Amines were determined and deducted from the total protein, the above results being expressed as true albuminoids.

Milk Yield and Milk Shrinkage (Pounds).

CHARACTER OF RATION.	Cows.	MILK PRODUCED AND SHRINKAGE.					TOTAL SOLIDS PRODUCED AND PER CENT. SHRINKAGE.				
		Total.	First Two Weeks.	Last Two Weeks.	Per Cent. Shrinkage.	Weekly Shrinkage (Per Cent.).	Total.	First Two Weeks.	Last Two Weeks.	Per Cent. Shrinkage.	Weekly Shrinkage (Per Cent.).
High protein, . . .	Mary, . .	4,224.7	341.4	173.6	49.2	2.0	567.3	44.3	25.7	42.0	1.7
	Chub, . .	3,684.1	263.6	173.4	34.6	1.2	483.5	33.1	22.7	31.4	1.1
	Betty, . .	4,086.0	343.4	208.4	39.3	1.5	599.6	49.9	29.7	40.5	1.6
	Cecile, . .	3,677.1	306.4	206.4	32.6	1.3	533.5	43.6	29.7	31.8	1.3
	Betty II., .	3,235.3	286.0	234.8	17.6	.89	430.2	39.6	30.1	24.0	1.2
Low protein, . . .	Minnie, . .	4,183.3	329.1	251.6	23.6	1.0	457.5	42.2	33.5	20.7	.9
	Samantha, .	4,370.0	305.5	231.9	24.1	.86	673.0	46.0	34.4	25.1	.9
	May Rio, . .	4,323.0	368.7	228.6	38.0	1.50	627.7	53.1	33.1	37.7	1.5
	Daisy, . .	3,643.5	352.9	202.4	42.6	1.8	545.9	50.1	30.0	40.2	1.7
	Red III., .	3,720.3	357.5	210.4	41.1	1.9	502.9	48.0	28.4	40.8	1.9
Average, high, . . .	. . .	-	-	-	34.7	1.4	-	-	-	34.0	1.4
Average, low, . . .	. . .	-	-	-	33.9	1.4	-	-	-	32.9	1.4

Influence of Protein on Milk Shrinkage (Average Results).

CHARACTER OF RATION.	Weight of Cow (Pounds).	Digestible Protein consumed daily per Cow (Pounds).	Percentage Excess of Protein over Requirements.	Total Shrinkage (Per Cent.).	Weekly Shrinkage (Per Cent.).
High protein, . .	900	1.83	22	34.7	1.4
Low protein, . .	906	1.39	3	33.9	1.4

The average amount of digestible protein consumed daily by each of the high-protein cows (1.83 pounds) was not quite as high as intended, hence the difference between the low and high protein rations was not particularly pronounced. Nevertheless, one would expect if the conditions were reasonably satisfactory that the low-protein cows would have shrunk in their milk yield (over an average of two hundred days) rather more than the high-protein cows. Such, however, was not the case, the shrinkage of both herds being substantially identical. The only explanation that can be offered is the undue influence of individuality and the small number of cows in each group. For example, Mary shrunk 49 per cent. during the experiment, it being characteristic of this animal to dry off quite rapidly after she had been four months with calf; Daisy also had such a tendency. The individuality of each animal, as well as its age and condition, all have a pronounced influence, especially when the experiment is extended over a long period of time, and in order to arrive at the truth a large number of animals must be used with as near similar conditions as it is possible to secure. Is it probable that if an animal receives sufficient protein to supply the daily demands of her body (maintenance) and of the milk produced, she will not shrink in her yield *during a milking period* any more than when she is receiving 25 to 50 per cent. protein in excess of the actual requirements? In other words, is it not possible that the excess protein acts as a stimulus for a time, after which the individuality of the animal becomes the more pronounced factor?

CONCLUSIONS.

The following general conclusions may be drawn from the experiments reported: —

1. A large excess of digestible protein (1.5 pounds, or 100 per cent.) above the protein minimum increased the flow of milk some 15 per cent. in experiments extending over periods of four weeks.

2. No particular difference was noted in the milk yield in case of two herds of cows receiving the same amount of total digestible matter, one receiving 65 per cent. and the other 122 per cent. of digestible protein above the protein minimum. Such a result indicates, at least, that the former excess was sufficient.

3. A 50 per cent. excess of digestible protein daily above the protein minimum in an experiment by the reversal method, extending over a period of nine weeks, produced some 5.9 per cent. more milk than did a ration with 21 per cent. excess protein.

4. Under similar conditions an excess, above the minimum, of 65 per cent. digestible protein produced 7.4 per cent. more milk than did an excess of 39 per cent. (experiment covered twenty-six days).

5. In experiment VI., extending over a period of eleven weeks with twelve cows, by the group method, an excess of .54 of a pound of protein, or 31.3 per cent., over the protein minimum, produced an apparent increase of 10 per cent. in the milk yield.

In experiment VIII., extending over periods of twenty-four to thirty weeks with ten cows, by the group method, the cows receiving the protein minimum did not shrink any more than those receiving each .44 of a pound, or 28 per cent., protein above the minimum.

6. The group method of experimentation is best suited for conducting experiments where a relatively large number of animals — twenty or more — is available. With a less number the influence of individuality is altogether too pronounced.

7. An excess of 30 per cent. of digestible crude protein above the protein minimum (equal to 1.80 pounds of protein per

day) will be productive of satisfactory results in case of cows weighing 900 pounds and producing daily 12 quarts of 4 per cent. milk.¹

An excess of 50 per cent. of digestible crude protein above the protein minimum is believed to be ample for all ordinary requirements.

8. Protein in excess of the above suggested amounts may temporarily increase the milk yield, but it seems probable that in many cases the influence of individuality is likely to be more pronounced than the effect of the protein consumed.

9. Under the usual conditions, varying amounts of protein appear to be without influence upon the composition of the milk.

¹ Armsby, in Farmers' Bulletin No. 346, United States Department of Agriculture, expresses substantially the same idea in allowing .05 of a pound of digestible true protein for each pound of average milk, in addition to the maintenance requirement of .5 of a pound of digestible true protein per 1,000 pounds live weight. It is possible that animals can even do very good work with .04 of a pound of protein for each pound of milk.

THE DETERMINATION OF ARSENIC IN INSECTICIDES.

BY E. B. HOLLAND.

During the past three years the writer ¹ has given considerable time to the study of arsenical insecticides, with special reference to their manufacture, composition and use, — the main object of which was to provide the entomological department of this station with chemicals of known composition, suitable for an extended investigation to determine their effect in practical application under varying climatic and atmospheric conditions.

For more than a decade the analysis of arsenicals has received marked attention because of the high value of a number of these salts as insecticides. The sale of inferior, adulterated or imitation products lacking in efficiency, or causing severe injury to foliage, has rendered necessary a certain amount of supervision by the agricultural experiment stations of the country. In several States special laws have been enacted to regulate the sale and to provide for an inspection of such materials. Arsenic as trioxide or pentoxide is the active constituent of these compounds, and various methods of several distinct types and numerous modifications have been proposed for its determination. Some of the methods are applicable to arsenous acid and others to arsenic acid.

METHODS.

As the work planned by the entomological department would require many analyses, it was desirable that the methods adopted should be reasonably short and simple, though accuracy would be the controlling factor. The literature on the determination of arsenic was reviewed at some length. The results, while somewhat overwhelming, can be roughly summarized under gravimetric methods, volumetric methods and processes for the elimination of substances liable to affect the determination. A

¹ Assisted by Dr. R. D. MacLaurin, Prof. S. F. Howard, C. D. Kennedy and J. C. Reed.

classification of this character is open to criticism, but will serve the purpose intended.

The gravimetric methods include the hydrogen sulfide precipitation of arsenous acid ¹ weighable as arsenous sulfide after removal of the excess sulfur; the Neher modification ² of the Bunsen method,³ precipitating arsenic acid with hydrogen sulfide, weighable as arsenic sulfide; the modified Levöl method, precipitating arsenic acid with "magnesia mixture," weighable as magnesium pyro-arsenate; and the Werther method,⁴ precipitating arsenic acid with uranyl acetate, weighable as uranyl pyro-arsenate. The inherent faults of the sulfide methods render them impracticable. The modified Levöl method, the most prominent of the gravimetric, is complicated, tedious and tends towards low results. All of these methods are time consumers, and none of them appear to have met with favor, having of late been almost entirely superseded by volumetric.

The volumetric methods include the Kessler method,⁵ oxidizing arsenous acid with potassium bichromate and titrating the excess chromic acid with standard ferrous sulfate, using potassium ferri-cyanide to determine the end point; the permanganate method, titrating arsenous acid with standard potassium permanganate to a rose color; the Mohr method, titrating arsenous acid with standard iodine in the presence of sodium bicarbonate, using starch paste as indicator; the Bunsen method,⁶ based on the difference in amount of chlorine evolved from hydrochloric acid by a given weight of potassium bichromate in the presence of arsenous acid, the gas being conducted into potassium iodide and the free iodine titrated with standard sodium thiosulfate, using starch paste as indicator; the Krickhaus method,⁷ reducing arsenic acid to arsenous with hydrochloric acid and potassium iodide, and titrating the free iodine with standard thiosulfate; the Bennett modification ⁸ of the Pierce method,⁹ precipitating arsenic acid with silver nitrate and titrating the silver in the precipitate with potassium sulphocyanate, according to Volhard;¹⁰ and the Bödeker method,¹¹ titrating arsenic acid with

¹ Fresenius, *Quan. Chem. Anal.*

² *Ztschr. Analyt. Chem.*, 32, 45 (1893).

³ *Ann. Chem. Pharm.*, 192, 305.

⁴ *Jour. Prakt. Chem.*, 43, 346 (1848).

⁵ *Poggend. Ann.*, 118, 17, Series 4 (1863).

⁶ *Ann. Chem. Pharm.*, 86, 290.

⁷ *Engin. and Min. Jour.*, 90, 357. See Sutton for earlier references.

⁸ *Jour. Amer. Chem. Soc.*, 21, 431 (1899).

⁹ *Proc. Col. Sci. Soc.*, Vol. 1.

¹⁰ *Liebig's Ann. Chem.*, 190, 1 (1873).

¹¹ *Ann. Chem. Pharm.*, 117, 195.

standard uranyl nitrate, using potassium ferrocyanide to determine the end point. The Kessler and Bödeker methods are objectionable in their requirement of an "outside" indicator. The Bunsen and Bennett methods are lengthy, and demand very careful manipulation. The permanganate titration is not as sensitive as the iodine, and the Krickhaus method offers no advantages in its application to arsenic acid over a similar reduction and titration with iodine. In other words, the iodine titration method (Mohr) seemed to us rather superior to any other in point of accuracy, manipulation and time, and was adopted for the work in view.

There are a number of processes that are noted more particularly as a means of eliminating impurities likely to effect the arsenic determination, among which may be mentioned the distillation processes of Fischer,¹ Piloty and Stock,² Stead,³ and Jannasch and Seidel,⁴ using hydrochloric acid in connection with reducing substances such as ferrous salts, hydrogen sulfide, and potassium bromide and hydrazine hydrochloride. The above list of methods is far from complete, but attention has been called to practically every type applicable to commercial products.

IODINE METHOD (MOHR).

As previously stated, the iodine method appeared to offer the greatest advantages, and was selected. A clear understanding of the character and limitations of the reaction underlying the method is necessary at the outset. Iodine is an indirect oxidizer, acting on the elements of water with the formation of hydriodic acid and the liberation of oxygen.



The oxidation cannot be conducted in an acid or neutral solution because of the reversible action of the hydriodic acid. If the latter is neutralized with sodium bicarbonate as rapidly as produced, the reaction will proceed to completion. Caustic alkali or carbonate cannot be employed, as they absorb iodine, the former being especially active. The reaction between starch

¹ Ztschr. Analyt. Chem., 21, 266 (1882).

² Ber. Deut. Chem. Gesell., 30, 1649 (1897).

³ Sutton, Vol. Anal., Edit. 9, 159 (1904).

⁴ Ber. Deut. Chem. Gesell., 43, 1218 (1910).

and iodine in the presence of hydriodic acid or soluble iodide is one of the most sensitive in analytical chemistry, forming the characteristic blue iodide of starch. A more delicate indicator could not be desired. Since the method was first applied to the analysis of arsenicals numerous modifications have been devised to insure complete solution of the arsenic, to prevent oxidation, to eliminate or render innocuous substances that might effect the titration, and to enlarge its field of application so as to readily include the arsenates. The Association of Official Agricultural Chemists began work on insecticides in 1899 and has rendered valuable service.

NEW PROCESSES.

The introduction of the Thorn Smith process ¹ marked a turning point in the analysis of arsenicals. It was intended particularly for Paris green, and is the official method for that substance. Solution of the arsenic is effected by boiling the sample with a slight excess of sodium hydrate, which readily unites with the free arsenous acid, and also with the combined after displacing the copper. In presence of a reducing substance like sodium arsenite, the copper is precipitated as cuprous oxide and a portion of the arsenous acid oxidized to arsenic. This oxidation necessitates a subsequent reduction of the filtrate with hydrochloric acid and potassium iodide (hydriodic acid), and the removal of the excess iodine with thiosulfate. The solution is neutralized with dry sodium carbonate, an excess of sodium bicarbonate added, and titrated with iodine. The process is accurate, though the double titration is objectionable.

Avery and Beans devised a very ingenious process ² noted for its simplicity. The Paris green is pulverized, solution effected with concentrated hydrochloric acid in the cold, neutralized with sodium carbonate, the precipitated copper redissolved with sodium potassium tartrate and titrated as usual. The copper held by the alkaline tartrate colors the solution but does not effect the titration. Hydrochloric acid, however, is a poor solvent for free arsenic, and unreliable, which constitutes a very serious objection to the process. Avery noted this error and advised ³ that samples showing a tendency to separate white

¹ Jour. Amer. Chem. Soc., 21, 769 (1899).

³ Jour. Amer. Chem. Soc., 25, 1096 (1903).

² Jour. Amer. Chem. Soc., 23, 485 (1901).

arsenic should be treated with N/2 hydrochloric acid, 5 to 10 cubic centimeters for each .1 of a gram, and boiled gently. In case arsenic remains undissolved, a cold saturated solution of sodium acetate, 3 grams salt for each .1 of a gram of substance, is added, and boiling continued until solution is effected. By another modification¹ suggested by Avery, and reported by Thatcher,² 1 gram sample is boiled five minutes with 25 cubic centimeters of sodium acetate solution (1-2), dissolving the free arsenic which is removed by filtration. The residue is dissolved in dilute hydrochloric acid and both solutions titrated.

Haywood attempted, in several ways,³ to modify the original Avery-Beans process so as to insure solution of the free arsenic. After treating the sample with a slight excess of hydrochloric acid at laboratory temperature, sodium carbonate was added and the solution boiled. In another case sodium bicarbonate was employed, but the results were unsatisfactory in both instances, due to more or less reduction of copper and accompanying oxidation of arsenous acid. Accurate results were secured, however, by filtering off the hydrochloric acid solution and boiling the residue with 5 grams of sodium bicarbonate, titrating both solutions.

Haywood proposed still another modification⁴ which might be considered a simplified Avery-Thatcher process;⁵ .4 of a gram sample is boiled ten minutes with 25 cubic centimeters sodium acetate solution (1-2) to dissolve free arsenic, and concentrated hydrochloric acid carefully added until solution is effected. After neutralizing with a solution of sodium carbonate, avoiding an excess, alkaline tartrate and sodium bicarbonate are added and titrated as usual.

The Avery, Avery-Thatcher and Avery-Haywood processes employ the same reagents, differing only in their application. The co-operative investigation⁶ of the association in 1904 showed that the three above modifications, together with the Haywood, gave closely agreeing results, with little, if any, advantage in the

¹ Optional official method, Assoc. Off. Agr. Chem.

² Proc. Assoc. Off. Agr. Chem., 20, 196 (1903).

³ Jour. Amer. Chem. Soc., 25, 963 (1903).

⁴ Proc. Assoc. Off. Agr. Chem., 20, 197 (1903). Optional official method of the association.

⁵ *Loco citato*.

⁶ Proc. Assoc. Off. Agr. Chem., 21, 93 (1904).

two-solution processes over the one. In 1905 the results ¹ with the Avery-Thatcher and Avery-Haywood modifications were not as satisfactory though the average difference was not excessive.

In weighing the merits of the Thorn Smith process and various modifications of the Avery-Beans, with apparently little choice as to accuracy, the Avery or Avery-Haywood process, with one titration of a single solution, certainly appeals to chemists in "control" work from the standpoint of manipulation, possible mechanical losses and time. This does not warrant any less care in conducting the analysis, but, if anything, demands greater attention. The essential features of the Avery-Haywood process have been employed at the Massachusetts station for the work on arsenites, though considerably modified as to detail.

PRACTICE AT MASSACHUSETTS STATION.

Having adopted Thatcher's suggestion ² as to ratio of sample to acetate solution, 1 to 25, and finding 25 cubic centimeters rather inadequate for proper boiling and agitation, double quantity of each is taken. To prevent slight loss of sample in transferring to flask, due to both adhesion and dusting, boats of folded filter paper are employed, and found very serviceable, particularly for Paris green and arsenic for standard solution. After boiling the solution five minutes with acetate, the directions call for the careful addition of concentrated hydrochloric acid until solution is effected. Such a procedure in our hands gave extremely variable results and generally a low test for arsenic. This error necessitated several weeks of experimenting, and was found to be due to the addition of *concentrated* acid, dilute acid (1-3) giving uniform results in practically every instance, and a higher test. Probably this has been one of the sources of trouble with the chemists reporting on association samples by the above process in past years. Neutralizing with sodium carbonate, in dry form or concentrated solution, will introduce an error if added in excess. The use of sodium bicarbonate is preferable for the purpose as the latter salt does not absorb iodine and eliminates an unnecessary reagent. As con-

¹ Proc. Assoc. Off. Agr. Chem., 22, 27 (1905).

² Proc. Assoc. Off. Agr. Chem., 21, 99 (1904).

centration has a certain influence on titration, it is advisable to maintain approximately the same volume in every case. The tendency of some solutions to become muddy on titration can often be relieved by additional bicarbonate, though the conditions involved seem to have no appreciable influence on the results. The quality of all reagents employed in the determination should be proved by blank tests, which should not exceed .10 of a cubic centimeter iodine solution for the amounts employed. Some lots of bicarbonate have been found unfit for such work. Due recognition should be given the blank in calculating results.

Considerable trouble is often experienced in determining insoluble matter with hydrochloric acid, due to the splitting off of white arsenic, especially with Paris green. To offset the difficulty it was found advisable to combine the determination with that of preparing the arsenic solution by simply filtering off the residue. The points noted above may be briefly summarized:—

Transfer 2 grams of finely ground sample, together with 50 cubic centimeters of sodium acetate (1-2), to a 500 cubic centimeter graduated flask, and boil five minutes. Cool under tap, add about 60 cubic centimeters of hydrochloric acid (1-3), and shake until solution is effected. Make to volume and filter. Pipette 25 or 50 cubic centimeters into an Erlenmeyer flask, neutralize with dry sodium bicarbonate, add 25 cubic centimeters of sodium potassium tartrate ¹ (1-10), to redissolve precipitated copper, approximately 3 grams of sodium bicarbonate, water sufficient to make a volume of 100 cubic centimeters, 2 cubic centimeters starch paste (1-200), and titrate with N/20 iodine to a permanent blue color. Toward the end of the reaction cork the flask and shake vigorously, to insure proper end point. Calculate results as arsenous oxide. The residue in the graduated flask is brought onto the filter, well washed, calcined in a porcelain crucible and weighed as insoluble matter.

The above process has given excellent results with copper aceto-arsenite, copper arsenite and calcium arsenite. Sodium acetate does not prevent hydrolysis of copper and calcium arsenites, as in the case of Paris green, but serves to take up free

¹ Used only with the copper arsenites.

arsenic. The presence of such impurities as cuprous and ferrous compounds, sulfurous and nitrous acids or other oxidizable substances is a source of error by the iodine titration method.

IODINE METHOD FOR ARSENATES.

The increasing use of lead arsenate as an insecticide resulted in a demand for a rapid volumetric method for the determination of the arsenic acid. The Gooch and Browning process,¹ as modified by Haywood,² serves to readily reduce arsenic acid to arsenous, in which form the iodine titration method is applicable. The process in our hands did not at first prove satisfactory, but eventually yielded concordant results after minor changes. As the differences are largely a matter of detail, not involving principle, only the modified process will be given.

Transfer 2 grams of finely ground sample, together with 60 cubic centimeters of nitric acid (1-3), to a 500 cubic centimeter graduated flask; bring to boil, cool, make to volume and filter. Pipette 50 or 100 cubic centimeters into a 150 cubic centimeter Jena Griffin beaker, add 10 cubic centimeters of sulfuric acid (2-1), evaporate, heat in an air bath at 150-200° C. to expel last traces of moisture, and then on asbestos board, to the appearance of dense white fumes, to insure complete removal of nitric acid. Add a small quantity of water, and when cold, filter through a sugar tube under suction into a 300 cubic centimeter Erlenmeyer flask, and wash to about 150 cubic centimeters. Add 10 cubic centimeters of potassium iodide (165-1,000) and boil until *free iodine is expelled*, — solution practically colorless, — with the reduction of arsenic to arsenous acid.



Dilute, cool immediately, neutralize approximately three-quarters of the free acid with 20 per cent. sodium hydrate solution, add starch paste, and if any free iodine remains, add dilute (N/50) thiosulfate carefully, with vigorous shaking, to the absence of blue color.



¹ Amer. Jour. Sci., 40, 66 (1890).

² Proc. Assoc. Off. Agr. Chem., 23, 165 (1906). Provisional method of the association.

Make up to about 150 cubic centimeters, add excess of sodium bicarbonate and titrate as usual with N/20 iodine, reporting as arsenic oxide. The residue in the graduated flask is brought onto the filter, washed, calcined and weighed as insoluble matter.

Care should be taken to have sufficient sulfuric acid to cover the bottom of the beaker when heated on asbestos. A decided excess of acid is also necessary when boiling with potassium iodide to insure vigorous action and rapid volatilization of iodine. Undue concentration should be avoided. If free iodine persists add more water and continue the boiling. The use of caustic soda is permissible under the conditions described. The hydrate is a much more convenient and rapid agent than the carbonate. Practically no difference was noted in the titration when the lead sulfate was allowed to remain, but the data at hand do not cover a sufficient number of samples to warrant a statement that this will always hold true.

The iodine method, as modified for arsenites and arsenates, has been given a careful study, and proved repeatedly, in the work at the Massachusetts station, to yield excellent results in the analysis of the insecticides mentioned, if reasonable attention is paid in following the details. While no radical changes in the method have been recommended, this article is offered in hopes that some of the points noted may prove of assistance to other analysts working along similar lines.

PURIFICATION OF INSOLUBLE FATTY ACIDS.

BY E. B. HOLLAND.

Workers in oils and fats experience the same difficulty in obtaining chemically pure products as investigators in other lines of organic chemistry. The best insoluble fatty acids on the market — judging from our experience — are unsatisfactory in both physical characteristics and neutralization number. In general appearance the acids that are offered resemble granulated curd, though varying in color from white to yellow, and contain considerable dust and dirt. The molecular weight, as measured by titration in an alcoholic solution, may deviate from the theoretical by 10 to 15 points. These statements apply to chemicals marked "C. P." and bearing the name of a reputable manufacturer or dealer.

The writer required stearic, palmitic, myristic, lauric and oleic acids for certain tests, and, finding it impossible to purchase them of the desired quality, was forced to undertake a study of various methods for their purification. As the character of the unsaturated acids is so unlike that of the saturated, only treatment of the latter will be considered at this time. The methods that seemed the best adapted for the purpose were (*a*) distillation of the fatty acids in vacuo, (*b*) crystallization from alcohol, and (*c*) distillation of the ethyl esters in vacuo, and all were given extended trial.

A. DISTILLATION OF THE FATTY ACIDS IN VACUO.

Direct distillation under reduced pressure was successfully employed a few years ago by Partheil and Ferie,¹ starting with Kahlbaum's best acids. Upon careful test the writer found that the method possessed certain objectionable features which render it rather impracticable for ordinary use. If it was merely a

¹ Arch. Pharm., 241, 545 (1903).

question of distillation of the acids the process would be less difficult, but for fractionation, using a Bruehl or similar type apparatus, it proved almost impossible, in case of the higher acids, to prevent solidification in the side neck (outflow tube). The danger arising from a plugged apparatus at the high temperature involved has also to be taken into account. An attempt was made to heat the tube and keep the acids liquid by means of a hot-water jacket, also by an electrically heated asbestos covering, but neither process fully met the requirements of the case. The slow distribution of heat in vacuo is, of course, one of the obstacles in the way. For the distillation of solids of high melting point Bredt and A. van der Maaren-Jansen¹ devised an elaborate piece of apparatus having a flask and receiver of special construction, and an overflow tube heated by electricity, but it is hardly suited for a general laboratory or for handling any considerable quantity of material.

There are two other conditions necessary for a successful distillation of fatty acids, namely, absence of moisture and a current of hydrogen or carbon dioxide to prevent bumping and to lessen decomposition. Overlapping of the acids in different fractions cannot be obviated entirely, and if an unsaturated acid was present in the original, it will probably appear in nearly every fraction.

Students under the direction of Professor Burrows of the University of Vermont have applied this process for a partial separation of the insoluble acids of several oils with a fair measure of success. With all due allowance for the possibilities of the method in the production of pure saturated fatty acids, the inherent difficulties render it inadvisable in most instances.

B. CRYSTALLIZATION FROM ALCOHOL.

Crystallization in this connection is practically limited in its application to the removal of a small amount of impurities, especially unsaturated acids. It can hardly be considered other than a supplementary treatment, though excellent for that purpose, to follow either of the distillation methods. Dry neutral alcohol suitable for such work can be prepared by distillation after treatment with caustic lime. In dissolving the acids care

¹ Liebig's Ann. Chem., 354, 367 (1909).

should be taken to avoid heating to a higher temperature than is required for solution, or to prolong the heating unduly, as it will cause the formation of esters. Several minutes' boiling of the different fatty acids in alcohol caused the following loss in neutralization number: —

Stearic acid,	1.70
Palmitic acid, . . . . .	.56
Myristic acid,	2.24
Lauric acid, . . . . .	.89
Oleic acid, . . . . .	.28

Esterification undoubtedly causes a serious error by this process of purification. Under more careful treatment the change is not as rapid as shown above, but is evidently cumulative and may even exceed the figures given. Further study may warrant the substitution of a more stable solvent, such as acetone. For the filtration a water or ice jacketed funnel is almost necessary, particularly for the acids of low melting point, and suction is a time saver. Repeated crystallization is needed to bring out the true crystalline structure and silvery luster of the leaflet. Vacuum drying at a low temperature is one of the most efficient means for removing adhering alcohol and traces of moisture without injuring the structure. Crystallization as a whole is wasteful of acids and solvent unless both are recovered, but is essential for the production of a superior product.

C. DISTILLATION OF THE ETHYL ESTERS IN VACUO.

As ethyl esters distill freely in vacuo, the process admits of a more ready application, and to products of a greater range of purity, than does a distillation of the acids. After considerable experimenting it was found that the esters are easily prepared by heating in an open flask equal parts (100 grams) of fatty acids and alcohol, together with a small quantity (10 cubic centimeters) of concentrated hydrochloric acid, using capillary tubes to prevent bumping. The reaction requires about thirty minutes, after which the excess of hydrochloric acid can be removed with a separatory funnel. The distillation is conducted in a 500 cubic centimeter "low" side neck flask, with a small (8 inch) Liebig condenser and a large size Bruehl frac-

tionation apparatus. Heat is furnished by means of a linseed oil bath, and suction by a pump of any type, using a mercury manometer to prove constancy of vacuum. The neck of the flask from the shoulder to an inch or more above the side tube should be wound with asbestos paper to prevent cracking, due to sudden changes of temperature. The condenser should be kept full of water, without circulation, to serve as a hot-water jacket. The vacuum should be as high as the flask will safely withstand, but above all uniform, otherwise the fractions are of questionable value. The temperature range of an ester also varies with the distance between surface of liquid and side tube. At least one redistillation of like fractions is necessary.

As the esters are very stable, more difficulty was experienced in finding some means for their quantitative decomposition than in any other portion of the work. Heating with mineral acids hydrolyzes the fatty acids very slowly, even under pressure. If, however, the esters are first saponified¹ by heating over a naked flame with twice their volume of glycerol and an excess of caustic potash until all the alcohol is expelled, and then the resulting soap dissolved in water and heated on a water bath with a slight excess of sulfuric acid, the separation is readily accomplished. This plan was suggested by the Leffmann-Beam saponification for volatile acids, and after extended trial proved the most thorough and rapid means for decomposing the esters. The resulting acid should be washed in a separatory funnel with boiling water until clear, and the cake allowed to drain. As previously stated, several crystallizations are necessary if a crystalline product of satisfactory melting point and neutralization number is to be secured. When crude acids are employed it is also advisable to crystallize at the outset to exclude a major part of the unsaturated acids, which otherwise would prove troublesome.

To summarize: saturated fatty acids may be purified by distillation of the acids or their ethyl esters. The latter method is less hazardous and easier to manipulate, although more steps are required. Crystallization is a finishing rather than an initial process of purification.

¹ Observing the usual precautions given for the determination of insoluble fatty acids, Massachusetts Agricultural Experiment Station, twenty-first report, p. 130 (1909).

THE SOLUBLE CARBOHYDRATES IN ASPARAGUS ROOTS.

BY FRED W. MORSE.

This paper is a simple statement of progress in a study of the composition of the asparagus plant, and is part of an investigation of the fertilizer requirements of asparagus now being conducted at this agricultural experiment station.

The nutrition of asparagus shoots in early spring necessarily depends on the material stored in the roots, since the mode of growth of the young shoots up to the time of cutting for the table renders assimilation from the atmosphere nearly impossible. Hence, roots were selected as the first portion of the plant to be studied.

A search of the literature of asparagus failed to show anything about the composition of the roots beyond a few scattering ash analyses and a brief article by Vines¹ on the reserve proteins.

Very recently, however, Wichers and Tollens² have reported an extensive study of asparagus roots, and called attention to similar work by Tanret,³ brief abstracts of whose articles had been overlooked.

Since the work has been wholly independent of that just mentioned, it is believed that this report of progress will be of value at this time.

All the material for the work here reported was prepared in other divisions of the department, and consisted of finely pulverized samples of individual root systems. All of the plant below the surface had been dug up, freed from earth and dried

¹ Proc. Royal Soc., 52, 130-132; Abstr. Jour. Chem. Soc., 64, 431.

² Jour. f. Landwirth., 58, 101-116.

³ Bul. Soc. Chem. (4), 5, 889, 893; Compt. Rend., 149, 48-50; Abstr. Jour. Chem. Soc. (1909), Abstr., 634; Chem. Abstr., 3, 2677.

at about 50° C. The roots were secured in November of the second year after setting, when translocation from the tops was believed to be complete. For subsequent study of the effects of different fertilizers the individual samples were separately analyzed; but for this report detailed results are unnecessary.

The average proximate composition of the dry matter of 16 roots was as follows:—

	Per Cent.
Protein (nitrogen x 6.25),	11.03
Fat,	1.00
Fiber,	15.39
Nitrogen-free extract,	66.34
Ash, ¹	6.24

The proximate composition showed clearly that the soluble non-nitrogenous matter included most of the reserve material of the roots.

The methods of the Association of Official Agricultural Chemists² for sugars, starch, pentosans and galactans were employed for estimating the different carbohydrates in the reserve material.

An examination of 25 roots showed 12 to contain no reducing sugars, while most of the others had only traces present; therefore reducing sugars were not estimated, but were reckoned with total sugars. The latter were especially abundant, and ranged from 26.4 per cent. to 50.8 per cent., only two samples containing less than 35 per cent. calculated to dry matter.

Pentosans were determined in 16 samples, and ranged from 7.32 per cent. to 10.68 per cent. in the dry matter. Galactans were determined in 4 individual samples and in a composite sample, but were insignificant in amount, averaging only 1.04 per cent.

In the estimation of starch by the diastase method, it was found that there was no more glucose obtained than was accountable from the diastatic extract. Subsequent examination revealed starch in only microscopic traces. Six different samples, after having undergone the diastase treatment as for starch,

¹ Ash determinations were made in the fertilizer division of the department.

² Bulletin No. 107, Bureau of Chemistry, United States Department of Agriculture, pp. 38-56.

were filtered and washed, and the residues then subjected to two hours' boiling under reflux condensers, with 100 cubic centimeters of HCl of approximately 6 per cent. After cooling the solutions they were nearly neutralized with NaOH, and made up to 250 cubic centimeters. The reducing sugars were then determined by Fehling's solution and the weights of copper calculated to glucose. The 6 samples averaged 8.6 per cent. of glucose by this hydrolysis; but since the same samples averaged 8.67 per cent. of pentosans, reckoned from furfurol-phloroglucid, it is improbable that there are any hydrolyzable carbohydrates unaccounted for by the usual analytical methods.

From these different analyses it was found that the dry matter of 16 roots contained —

	Per Cent.
Sugars calculated as invert sugar,	41.43
Pentosans,	8.78
Galactans,	1.04

The carbohydrate forming over 40 per cent. of the dry matter was at first assumed to be sucrose. The analytical procedure had shown it to be soluble in cold water and inactive to Fehling's solution until hydrolyzed, which was easily accomplished by dilute acids. Repeated attempts to recover sucrose by means of strontium hydrate¹ resulted in securing only very small quantities of a straw-colored syrup which could not be crystallized, but did not reduce Fehling's solution.

Methyl alcohol was found to extract considerable quantities of the sugar from the roots, which suggested raffinose; but no mucic acid could be obtained by oxidation with nitric acid, although a parallel test with lactose under the same conditions yielded it in abundance.

Osazones were prepared from both methyl alcohol and water extracts, before and also after inversion. The characteristic yellow, crystalline precipitate was easily obtained in every case. Five such precipitates had their melting points determined, and they ranged between 203 ° and 210 °, and were accompanied by an evolution of gas. Glucosazone was evidently the only one formed.

¹ E. Schulze, *Zeitschr. Physiol. Chem.*, 20, 513-515.

About 100 grams of roots were extracted by cold water and the extract concentrated on the water bath to a thick, black, tenacious syrup, which was strongly reducing to Fehling's solution. Heat and probably acid salts had brought about a nearly complete hydrolysis during the evaporation. This extract failed to yield mucic acid, but oxalic acid was readily formed.

Portions of the syrup were subjected to distillation with HCl of 1.06 specific gravity, and yielded a small quantity of furfural. The furfural-phloroglucid, after being dried and weighed, was found to lose about two-thirds of its weight by solution in hot 93 per cent. alcohol, indicating that it was largely methyl-furfural.

The action of polarized light was observed upon freshly prepared water extracts of two different roots, and upon three syrups which had been fractionated by strontium hydrate. The solutions were clarified by lead subacetate, and the readings were made in a Schmidt and Haensch triple shade saccharimeter through a 200 millimeter tube. The solutions were then inverted and again polarized, together with two solutions of the dense water extract above mentioned.

Subsequent to the readings, the actual strength of sugar in each solution was determined with Fehling's solution. The solutions were necessarily dilute, because the roots on moistening swelled to a large volume and small charges had to be used. The three syrups were small in amount, as before mentioned, and the black syrup from the water extract was difficult to clarify to a point where light would pass through it.

Polarization before Hydrolysis.

	Sugar in 100 Cubic Centimeters (Grams).	Saccharimeter Reading.	Specific Rotatory Power (Degrees).
Root 34,	1.738	+0.5	+5.0
Root 40,	2.259	-1.4	-10.0
Syrup A,	2.623	+2.88	+18.9
Syrup B,	2.775	-1.6	-10.0
Syrup C, . . . . .	.858	zero	zero

Polarization after Hydrolysis.

	Invert Sugar in 100 Cubic Centimeters (Grams).	Saccharimeter Reading.	Specific Rotatory Power (Degrees).
Root 34, . . . . .	.893	—2.33	—45
Root 40,	1.189	—4.10	—59
Syrup A,	1.381	—3.45	—49
Syrup B,	1.461	—5.25	—62
Syrup C, . . . . .	.452	—1.30	—49
Extract 1, . . . . .	.936	—3.00	—55
Extract 2,	2.350	—7.80	—57

The action on polarized light both before and after inversion excludes the possibility of the carbohydrate being pure sucrose, while the failure to secure it with strontium hydrate renders its absence probable.

Fructose was clearly demonstrated by the osazone and the negative optical activity, also by fine reactions with resorcin and hydrochloric acid. Glucose is indicated by the osazone and the fact that the specific rotatory power of the inverted solutions is not high enough for pure fructose. Fructose clearly predominates over the glucose, and the non-reducing property before hydrolysis indicates some condensation product formed between them. The behavior of individual root extracts does not point to any fixed proportion of the two sugars.

These results are, on the whole, in close agreement with those of Wichers and Tollens. There was, however, a marked difference in the behavior of the water extract of the roots, which contained the sugar-like carbohydrate. Wichers and Tollens used boiling water, and state that only a portion of this carbohydrate was soluble in water when extractions were made on the water bath. Their solutions also reduced Fehling's solution before hydrolysis.

My extractions were all made with water at 20° C., and until hydrolyzed, had either no reducing action or precipitated no more than traces of copper.

This difference in solubility and reducing action is doubtless

due to the stage of development of the roots, since Wichers and Tollens worked upon roots gathered in April and July instead of in November.

Tanret isolated two distinct crystalline carbohydrates from the root sap, one of which had a rotation of -35.1 and the other $+30.3$. Syrups A and B fractionated with strontium hydrate showed opposite rotations before inversion, but lack of material has given no opportunity to confirm further his observations.

Grateful acknowledgment is made of suggestions received from Dr. Joseph B. Lindsey during the progress of this investigation.

SEED WORK, 1910.

BY G. E. STONE.

The seed work for 1910 includes seed germination, separation and the testing for purity. The number of samples of seed sent in for germination exceeded that of 1909, the total number being 296. This germination work seems to be on the increase from year to year, and a great many more varieties of seed are tested for germination than has been the case in the past. Of the total number of samples sent in this year, 152 were miscellaneous seeds, a trifle over 50 per cent. of the total number. The number of samples of onion seed sent in was a little less than in 1909, and tobacco averaged about the same. The average germination of the tobacco seed, 95 per cent., was slightly better than usual. The lowest germination of any sample of tobacco seed sent in was 89 per cent. On the whole, onion seed last year did not seem to be up to the previous year's standard, as the average germination of all samples was only 77.4 per cent., as against 82.2 per cent. in 1909. The germination of the tobacco seed, with a lowest percentage of 89, tends to prove the theory that large seeds produce large plants; therefore in succeeding years better crops are obtained, and, as a result, better seed.

TABLE 1. — *Records of Seed Germination, 1910.*

KIND OF SEED.	Number of Samples.	Average Per Cent.	PER CENT. OF GERMINATION.	
			Highest.	Lowest.
Onion,	75	77.4	100.0	3.0
Tobacco,	7	95.0	99.0	89.0
Lettuce,	41	77.7	100.0	15.0
Cucumber,	10	93.7	99.0	85.0
Alfalfa,	4	98.2	100.0	97.0
Clover,	4	93.0	97.0	88.0
Red clover,	3	100.0	99.5	98.5
Miscellaneous,	152	66.0	100.0	—
Total,	296	—	—	—

The work in seed separation for 1910 was carried on as usual, and although a smaller number of samples was separated than in 1909, the total amount of seed separated, 1,552 pounds, was greater. Of this, 1,183 pounds were onion seed. The principal varieties of seed separated were onion, tobacco and lettuce. The separation of onion seed also tends to show that the seed was not as good this year as it was in 1909, as the average percentage of good seed was only 88.7 per cent., while the amount of discarded seed was slightly larger than in 1909. As in years past, several growers have requested that this station test the germination of seed both before and after separation, and the results this year resemble those of previous seasons so closely that they will not be inserted in this report. In the case of the separation of lettuce seed, the grower sending the seed often requests that a certain amount, sometimes in excess of the actual need, be taken out. This, however, is believed to be a good practice in the case of lettuce or tobacco seed, as it is certain that better germination results from removing more than is absolutely necessary. Table 2 shows the records of seed separation for 1910.

TABLE 2. — *Records of Seed Separation, 1910.*

KIND OF SEED.	Number of Samples.	Weight (Pounds).	Per Cent. of Good Seed.	Per Cent. of Discarded Seed.
Onion,	40	1,183.82	88.7	11.3
Tobacco,	62	44.96	89.6	10.4
Lettuce,	13	323.45	74.4	25.6
Total,	115	1,552.23	—	—

No effort has been made on the part of the station as yet to establish and maintain a seed-control laboratory for the purpose of testing the purity of seed, and therefore in the past year the number of samples of seed sent in for examination as to their purity has been small. In all, some 30 samples have been examined; mostly clovers and grasses, but as this work takes considerable time, no grass mixtures have been examined for purity.

The station is always glad to receive samples of seed for germination, and it is believed that if the farmer would send his seed in for examination for purity also, he would very often save himself a great deal of trouble and expense, as much of the seed sold in this State is full of weed seeds. It is believed that there should be a seed-control act in Massachusetts, as has been stated in our previous reports, and the sooner this comes the better the farmer will be served by the seedsmen, since they are perfectly willing to handle good seed if it is what the farmer wants and demands.

All samples of seed to be germinated or separated should be addressed to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass., and the express or freight on these seeds should be prepaid.

AN OUTBREAK OF RUSTS.

BY G. E. STONE.

For the past three years certain rusts have increased materially in this State as well as in other sections of the United States. The rust on the apple, which has been scarcely noticeable for years, at least on our cultivated fruit trees, has become quite common the last three seasons. It was particularly prevalent three years ago, and quite a little of it has been noticed on apple leaves the past two years. The hawthorne (*Cratægus*), a plant closely related to the apple, has shown a much greater tendency to rust in the period above mentioned than formerly, and some anxiety has been felt by nurserymen who have had to contend with this in their nurseries.

The ash rust, which is supposed to have as one of its hosts the grass known as *Spartina*, has occurred much more commonly than usual during this period. It is to be found on young growths of ash trees, distorting the twigs. There have also been severe outbreaks of the bean rust lately, although this has given little trouble in former years; and the hollyhock, rose and quince rusts have been much more common than formerly.

SWEET PEA TROUBLES.

BY G. E. STONE.

One of the most unsatisfactory types of troubles with which the pathologist has to deal is that having no specific organism as its primary cause. It is especially difficult to diagnose such diseases where the conditions of growing the plants are almost entirely unknown, and this is the case with most of the miserable, sickly looking sweet pea plants sent into the laboratory for diagnosis. There may be well-defined troubles associated with sweet peas, but from 90 to 100 per cent. of them may be prevented if the grower has even an elementary knowledge of the conditions required by this plant.

When sweet peas are planted in poor soil, without care or preparation, unfavorable results may be looked for. That such is too often the case is evident from an examination of the material which is sent in for examination. To obtain a good crop of sweet peas unusual care should be given to preparation. A light soil is better than a heavy, compact soil. It is impossible to grow this crop without a good depth of garden loam, and, if this is not available, it must be secured by deep trenching and heavy manuring. Most skillful gardeners maintain that the best results are obtained by having a soil which the sweet pea roots can penetrate deeply, and in which they can develop luxuriantly.

A trench $1\frac{1}{2}$ to 2 feet deep and the same width, filled with manure and loam, is usually sufficient. If a good depth of root development is desired, it is best to sow the seeds in trenches 4 to 6 inches below the surface, and as the plants mature the soil can be gradually hoed around the stems. The many specimens which we receive from growers testify to the poor conditions in which the plants have been grown, there being little root or stem development, and often tubercles on the roots are lacking. Proper conditions count very much in growing sweet peas, and when these are given, many so-called "diseases" peculiar to this plant disappear.

A SPINACH DISEASE NEW TO MASSACHUSETTS.

BY HARRY M. JENNISON, B.S.

Early in the spring of 1910 the writer's attention was attracted to a plot of winter spinach growing on the college grounds which had been practically ruined by a fungus causing a spotting of the leaves. The olivaceous color of the spots on the diseased leaves suggested the possible presence of a *Cladosporium* as the causal organism, but upon microscopical examination the fungus was determined to be *Heterosporium variable*, Cke. This organism is closely related to that causing the *Heterosporium* disease of cultivated carnations, known as "fairy ring."

It was supposed that a disease which could so completely devastate this crop would have been extensively reported, but upon thorough search of the literature only a few references to this particular spotting of spinach could be found. In 1905 Clinton¹ reports having collected in the open market in New Haven, Conn., specimens of spinach leaves affected with the above-mentioned fungus, and he refers to it as "leaf mold." Halsted² in his investigations on the fungi attacking the spinach plant does not include *Heterosporium* in his list. Since 1908 Reed³ has been studying its occurrence and injurious effects in the truck crop regions of Virginia, where it causes large losses annually to the truck farmers of that State. At Amherst the disease was found infecting winter spinach, growing on two widely separated plots. Immediately adjacent to one of these was a considerable area set with young spinach

¹ Clinton, G. P., Connecticut Agricultural Experiment Station, report for 1905, Part V., p. 275.

² Halstead, B. D., New Jersey Agricultural Experiment Station Bulletin No. 70, 1890.

³ Reed, H. S., in Virginia Agricultural Experiment Station circular No. 7, revised edition, p. 80, 1910.



Showing *Heterosporium* Disease of Spinach.

plants for the late spring crop. Careful examination, however, failed to reveal any indications of this disease on the young plants. As has been suggested, this fact seems to indicate that the causal organism is not a true parasite, and that it cannot infect healthy, vigorous plants, being more probably one that is capable of infecting its host only after the latter has become weakened by adverse climatic conditions, or injuries produced by other causes.

Further observations upon this interesting phase unfortunately could not be made, but in a recent text-book on the "Diseases of Economic Plants" ¹ the following statement is found:

"The disease does not seem capable of attacking healthy, vigorous plants, but usually follows injuries produced by other agencies."

The first indications of the presence of the disease are sub-circular areas of dead tissue from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch in diameter and brownish in color. (See cut.) These spots soon become more noticeable by the development of a greenish-black felt of fungous mycelium, bearing conidiophores and conidia, on both the upper and lower sides of the leaf. The spots are frequently more numerous toward the apex of the leaf, and by the time the fungus felt is well developed, the intervening leaf tissue is yellowed and presents a sickly appearance. Often the leaf is so badly infected that the diseased areas coalesce, leaving very little of the leaf tissue visible.

The market value of the crop is lessened if the leaves are at all spotted, and when badly diseased it is not salable. Even if the whole plant does not collapse from the effects of the fungus, it is greatly injured, and trimming off the injured leaves necessitates extra labor and expense at harvest time.

Since the disease is new to this locality, and there have been such limited opportunities to study it and the factors responsible for it, it is impracticable to offer any remedies at present. If the disease is sporadic, and caused by adverse conditions, the proper remedy would be to find out what those conditions are and remedy them. On general lines, however, it would be well

¹ Reed, in Stevens & Hall's "Diseases of Economic Plants, — Heterosporiose," p. 288, 1910.

to employ sanitary methods in growing the crop, to use seed from healthy and vigorous plants, and try to prevent injuries from insects, etc.

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ABNORMALITIES OF STUMP GROWTHS.

BY GEORGE H. CHAPMAN.¹

For the past few years there have been called to our attention on stump land and burned-over wood lots various malformations and abnormalities of the leaves of sprouts growing from the stumps; and in connection with other physiological work being done in the laboratory,² these conditions were studied, with the idea of discovering, if possible, the cause and relationship to other physiological diseases, such as those arising from malnutrition; also mosaic disease, overfeeding and œdema.

These diseases are all different in character, but it might be well to give a brief description of them at this point.

Overfeeding, particularly with nitrates, may be recognized by a slight increase in size of leaf, the color being darker and the leaf stiffer in texture. The cells of the leaf, with the exception of the bundles, are normal in form and are larger, but the bundles are distorted, and this causes a distortion of the leaf, due to the form of the bundles. The leaf is usually somewhat larger than normal, and the distortion curves the edges of the leaf downward, *i.e.*, rolls them toward the under side.

All investigators agree that the mosaic disease is purely a physiological one, but there seems to be much doubt as to whether it is infectious or contagious in character, or both. There seems to be some difference in opinion, also, as to the direct cause of the disease. In tomatoes it is always produced when the vines are heavily pruned, and in the work here it has been shown that it is connected in no way with methods of transplanting the young plants, and only results from subsequent pruning.

It has been found that tobacco is much more susceptible un-

¹ Presented as part work for degree of M.Sc.

² Dept. of Veg. Phys. and Path., Mass. Agr. Exp. Sta.

der conditions which tend to produce the disease than is the tomato.

In the case of tobacco, A. F. Woods¹ found that when a plant was grown in soil containing small roots of diseased plants the disease occurred in a short or long period of time, as the case might be. In our observations on the tomato we have been unable to verify this statement, as in no case has the disease appeared when normal plants were grown in soil which contained roots of plants which had been badly diseased, and in the growing of tomatoes year after year in the station green-houses there has never been the slightest evidence of infection arising from the soil.

In the case of the tomatoes grown under glass, the disease did not make its appearance when the plants were left normal, but occurred when the plants were pruned. These conditions held true for soils in which there were diseased roots as well as for those in which tomatoes had not previously been grown.

The appearance of mosaic disease has been described by many investigators, and nearly all have described it in a similar manner, but more particularly with reference to tobacco than to the tomato. The general characteristics of the disease are the same for both plants, but some difference is found in its appearance in extreme cases on the tomato, as will be noted from the following description.

In the first stages of the disease the leaf presents a mottled appearance, being divided into larger or smaller areas of light and dark green patches. At this point, however, no swelling of the areas is noticeable, but as the disease progresses the darker portions grow more rapidly, while the light-green areas do not grow so rapidly, and leaf distortion is brought about. In the case of tomato, the light-green areas become yellowish as the disease progresses, and in badly affected plants become finally a purplish red color. This purplish coloration is found principally on plants which are exposed to strong light, but does not always occur, as it has been found that sometimes, even in badly infested plants, the disease may reach its maximum without showing any reddish coloration whatever. The reddish

¹ U. S. Dept. Agr., Bur. of Plant Ind., Bul. No. 18.

appearance is noticeable only on the upper surface of the leaf, and appears to extend only through the palisade cells. As yet no investigation has been made with reference to its character, but from its appearance under the microscope it is thought that it may be due to the breaking down of the chlorophyll granules as a result of the diseased condition of the leaf.

Under all conditions of disease, however, the leaves are much distorted and stiff, and often very badly curled, usually with the edges rolled up over the leaf, and never possessing the flexibility of healthy, normal leaves.

Edema is perhaps the least liable to be confounded with other physiological troubles as its appearance is more strongly characteristic. Only a brief description will be given here, as this trouble does not enter into the discussion in this paper. Usually the leaves, as a whole, hang pendent, but the leaflets curl strongly upward; on close examination it is found that the veins, midrib and surface of the leaf show elevated more or less frosty areas, somewhat resembling the masses of conidia of some of the *Erysiphæ*; although in mild cases this condition is not striking, but the leaves usually have a more or less pearly luster at some stage of its development. The epidermal cells are very much enlarged in these areas and turgid, and the chlorophyll-bearing cells are also greatly changed. For a detailed description and discussion of this trouble no better work can be found than that of G. F. Atkinson.¹

It can be seen from these brief descriptions that unless care were exercised it might be easy to confound these troubles, especially in the case of the first two. Keeping this in mind we will pass on to a more detailed description of the malformation of stump growth subsequent to the burning off or cutting down of large trees.

The malformation appears to be worst in the first two or three seasons' growth, the sprouts outgrowing the trouble as their age increases. From our observations this trouble appears to occur in two distinct forms: first, as an abnormal growth of stem and leaves, they sometimes reaching a size five to ten times that of normal young plants of the same species. This form of the

¹ N. Y. (Cornell Univ.) Agr. Exp. Sta., Bul. No. 53, "Edema of Tomato."

leaf was especially noticeable in such sprouts as ash, poplar and plane tree, and sometimes occurred also on chestnut and oak, although it may be mentioned that they were occasionally very much distorted.

When the leaves were simply abnormally large it was found that the structure of the cells and their relative positions were analogous to a healthy, normal leaf, but that they were relatively much larger, and were of a stiffer texture than the normal specimens.

Very often it was found that the cell contents, especially the coloring matter, were brought into undue prominence, richly colored red leaves being of frequent occurrence. Occasionally, also, leaves having a decided yellow color, but otherwise appearing strong and healthy, were observed. This excessive coloration was evidently due to the abnormal deposition of pigment or activity of colored cell sap. When the leaves were green, the color seemed to be deeper than that of normal specimens.

The second form of the malformation has much the appearance of that caused by overfeeding, or excessive use of nitrates; *i.e.*, a severe distortion of leaves, but in this case accompanied by excessive production, usually smaller in size than the normal, but thickly clustered. Distorted leaves did not usually show much abnormal coloration, but occasionally a reddish or yellowish color was observable.

Usually the leaves were much more numerous and very badly distorted, the veins and ribs being especially twisted in various ways. The texture of the leaf was very stiff, much more so than in the case of the abnormally large leaves, the tissue having hardly any elasticity, and breaking easily, with a crackling sound. Plates I. and II. (Figs. 1, 2 and 3) show the two forms of this trouble better than mere description.

There is a remarkable dearth of literature bearing on this specific trouble, although much has been written in a general way on somewhat similar physiological troubles, but dealing principally with field crops and forced plants. In the reports of the various experiment stations will be found more or less literature on physiological troubles, and Woods,¹ Suzuke,² Stur-

¹ U. S. Dept. Agr., Bur. Plant Ind., Bul. No. 18.

² Bul. Col. Agr., Tokyo, Vol. IV., repts. for 1900.



FIG. 1. — Chestnut (*Castanea dentata*), showing Diseased (Left) and Healthy (Right) Shoots.



FIG. 2. — Red Oak (*Quercus rubra*), showing Diseased (Left) and Healthy (Right) Shoots.





FIG. 3.—Poplar (*Populus grandidentata*), showing Diseased (Right) and Healthy (Left) Shoots.



FIG. 4.—Mosaic Disease on Tomato.



FIG. 5.—White Oak, showing Diseased Shoot.



PLATE III.

FIG. 1. — Mature pycnidia, showing a few unicellular hyaline spores and orifice from which they have been expelled.

FIG. 2. — Nearly mature pycnidia, with attached *Alternaria* spores.

FIG. 3. — Mycelium threads giving rise to *Alternaria* spores and an immature pycnidium.

FIG. 4. — Common type of *Alternaria*.

FIG. 5. — Conidial form of *Cladosporium* developed from microsclerotia found on gummy excretions.

All from camera lucida drawings.

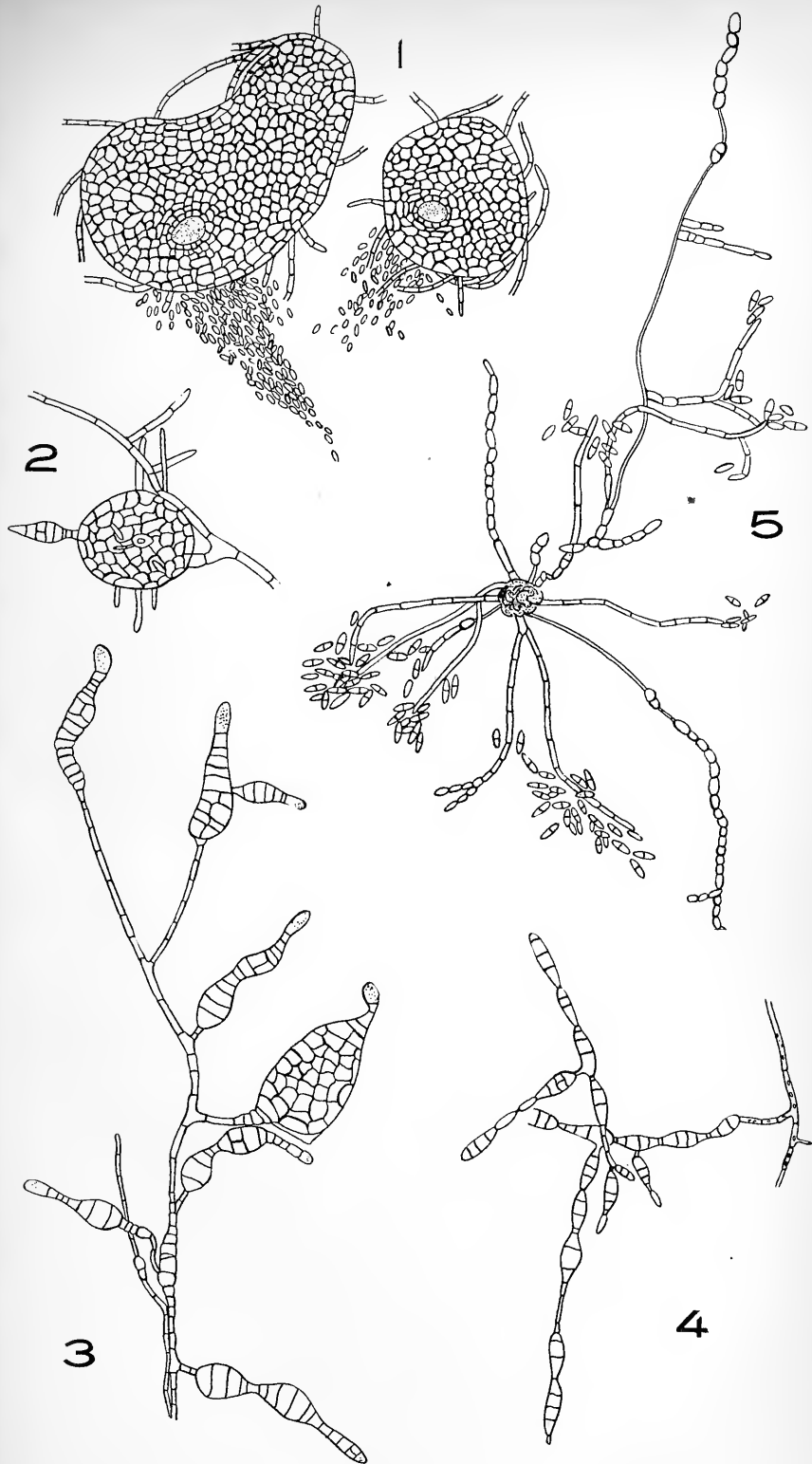
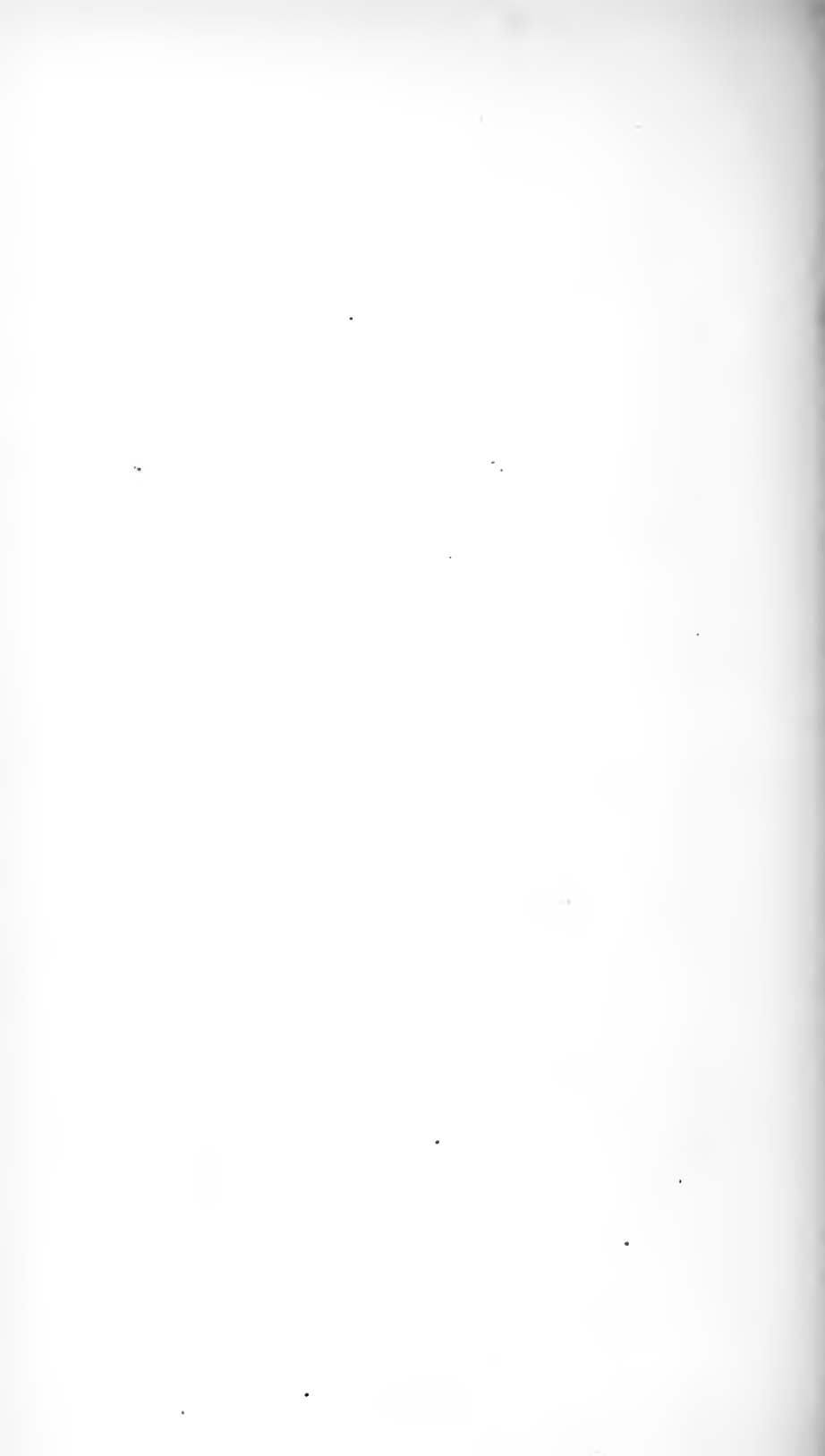


PLATE III.



gis,¹ Czapek,² Stone,³ Atkinson⁴ and others have dealt with various physiological troubles more in detail.

From our observations and experiments in the field and greenhouse we have come to the conclusion that it is a well-developed form of malnutrition, using malnutrition in its broadest meaning, *i.e.*, to include any physiological trouble which is caused by an excess or lack of any one or more nutritive substances necessary for the normal metabolism of a plant, and is allied to the phenomena exhibited in a severe case of overfeeding.

Logically it is what one would expect when a large tree is suddenly cut off or the top killed, and practically all transpiration, respiration, or, in short, all photosynthesis and leaf metabolism, is suddenly arrested. We have a violent disruption of the normal metabolism of the tree. The balance between root absorption, photosynthesis, etc., and the metabolic processes of the leaves is suddenly broken, and we have the roots, which are still alive, attempting to do their normal work without the aid of the leaves; starch formation is arrested and carbon assimilation cannot take place. In the roots there remains a great reserve store of food and during the winter no root pressure. As most woods are cut in the fall and winter, the trees are dormant, and forest fires also occur largely in fall and spring during this dormant period. Now, when spring comes and circulation starts, the adventitious buds are called upon to produce new shoots for the utilization of the reserve food in the roots. This they try to do in the manner we have described, by producing abnormally large leaves or a great number of small and distorted leaves. This distortion will be discussed later.

Of the trees which have come under our observation, maples, oaks and chestnuts seem to be the most susceptible to leaf distortion, while such trees as the ash, poplar and plane usually have abnormally large leaves with very little distortion. However, in some cases both conditions are observable.

The theory which has been advanced above as to the cause of the disease has been borne out by experiments carried on in the

¹ Conn. Agr. Exp. Sta., 1898, and others.

² Biochemie der Pflanzen (general).

³ Mass. Agr. Exp. Sta. reports.

⁴ N. Y. (Cornell Univ.) Agr. Exp. Sta., Bul. No. 53.

field and laboratory. The results of these experiments will be discussed later in the paper.

RELATION TO MOSAIC DISEASE.

It was at first thought that there might be some relation between the so-called "mosaic disease" and this, but from our observations we have been able to find only a superficial relationship, *i.e.*, as regards the distortion of the leaf in its first stages. Other investigators,¹ as has been previously mentioned, have proved that the "mosaic disease" can be communicated from one plant to another by inoculating a healthy plant with the juice of a diseased plant, and that the new growth subsequent to the inoculation will come diseased in nearly every case. This is not so in the case of sprout growth, however, as in no instance were we able to bring about a diseased condition of normal plants by inoculating them with juice taken from diseased leaves. As it was impossible to carry on these inoculation experiments in the laboratory, the work was done in the field, and observations taken from time to time.

EXPERIMENTS IN INOCULATION.

In order to prove that, unlike mosaic disease, this malformation could not be communicated from a diseased sprout to a healthy one, the following experiments were made. Two series of ten inoculations each were made; in one case diseased tissue was inserted at the base of the terminal bud of normal, healthy sprouts; in the second series the terminal buds of healthy sprouts were inoculated with the filtered juice from diseased plants. In all cases a healthy plant was inoculated with the tissue or juice of a malformed plant of the same kind, *i.e.*, a maple was inoculated with juice from a diseased maple shoot, etc. In not one case could we find that the trouble was either contagious or infectious in character. The results of these inoculations are given in Table I., and from these results it is evident that the disease cannot be communicated from one plant to another.

¹ A. F. Woods, U. S. Dept. Agr., Bur. Plant Ind., Bul. No. 18.

TABLE I.

SERIES A. — *Showing Results of Inoculation of Healthy Young Growth with Tissues from Malformed Plants.*

PLANT.	Number inoculated.	Number diseased.	Remarks.
Maple (<i>Acer rubrum</i>), . . .	10	None.	The terminal bud died in two cases, but this was due to mechanical injury.
Chestnut (<i>Castanea dentata</i>), . .	10	None.	
Oak (<i>Quercus alba</i>), . . .	8	None.	
Poplar (<i>Populus tremuloides</i>), .	10	None.	The terminal bud died in three cases, but this was due to mechanical injury.

SERIES B. — *Filtered Juice used for Inoculation.*

PLANT.	Number inoculated.	Number diseased.	Remarks.
Maple (<i>Acer rubrum</i>), . . .	14	None.	Inoculated twice two weeks apart with juice.
Chestnut (<i>Castanea dentata</i> , Borkh.),	11	None.	
Oak (<i>Quercus alba</i>), . . .	10	None.	
Poplar (<i>Populus tremuloides</i>), .	10	None.	
Ash (<i>Fraxinus Americana</i>), . .	5	None.	

The appearance of the leaves of "mosaic" plants is usually different from that of diseased shoots in the case under discussion. In mosaic these are flattened areas of cells which are lighter in color than the normal areas, and which are also smaller in size, growing more slowly than the normal cells, this causing a general unevenness or distortion of the leaf.

On the other hand, in the trouble under discussion, where abnormality occurs, the tissue of the leaf itself is not so much distorted as the vessels and veins. These are usually curved more or less, and thus distort the leaf. The leaf, also, is always of a healthy dark-green color, and shows no division of color into light and dark areas. Plate II. (Figs. 4 and 5) shows a typical mosaic leaf and some from affected sprout growth.

The cause of mosaic is not exactly known, but it has been produced repeatedly by severe pruning in the case of tomatoes,

tobacco and other allied plants. It occurs on tobacco, also, without pruning in the field, due to some functional disarrangement in all probability; but in the case of tomato we have not been able to find a case in which the disease occurred on a plant which was allowed to grow normally, that is, without pruning. Plants in the field are also not so susceptible to it, and it is rather difficult to conceive just why it is that under similar conditions, but with different plants, we sometimes get the characteristic mosaic disease and sometimes only a condition such as the one under discussion.

RELATION OF ROOT AREA TO INTENSITY OF DISEASE.

In the course of our experiments it was observed that in the same locality, with the same kinds of trees, there was a marked difference in the intensity or severity of the malformation. It was thought that the size of the original tree and its corresponding root area might bear some relation to the severity of the disease. Rough estimates were made of several root systems from which first-year sprouts were growing which were diseased, and in general it was found that the larger the root area the more distortion of the leaves. This seemed to be the general rule, but from the limited number of observations we were able to make it would be unwise to make a positive statement as to the absolute truth of this observation.

When young trees had been cut down or killed by burning, there was not such severe distortion, but more of a tendency to produce abnormally large leaves. As a result of our observations it may be stated that there is a relationship existing between the amount of active root surface and the severity of the trouble along the lines we have pointed out.

It has been stated elsewhere in this article that the severity of the disease diminishes from year to year as the plant grows older, and it would be natural to expect such a recovery for two reasons: first, the shoot is larger the second year than the first, thus having more leaf surface to effect transpiration, respiration, carbon assimilation, etc.; and secondly, some part of the root system, owing to lack of food (available), which the first year's leaves have been unable to supply, has died from general

weakening; thus the second year, and so on from year to year, we have a general attempt to balance up the root system and the leaf system. It is believed that this view is in accordance with the truth, although no specific work has been done here to prove it other than general observations.

CHEMICAL TESTS OF ABNORMAL LEAVES.

In view of the fact that physiological diseases in general are principally caused by derangement of the function of some organ of a plant, as a result of poor nutrition (lack or excess of some necessary plant food), it was thought that it would be well to obtain, in a general way, an idea as to the presence and absence of certain substances in the leaves of diseased plants. Owing to pressure of other work it was necessary to use dried specimens for examination. The specimens, however, were not over one or two months old when the examinations were made, therefore no great change of constituents could have taken place, with the exception of loss of water, and this was not of any importance. A complete analysis was not made of the leaves, but comparative tests were made, comparing the substance in healthy leaves with the same amount of diseased leaves. The substances tested for were principally nitrates, enzymes and starch.

As Woods¹ in his bulletin on mosaic disease advances the theory that it is caused by an excessive amount and increased activity of oxidizing enzymes, such as oxidase and peroxidase, equal amounts of leaves from healthy and diseased leaves were tested to see if there was any increase or decrease in the relative amounts present. It was found that in general there was usually present in diseased leaves a slightly larger amount than in the healthy leaves, but it was not necessarily so, as in five cases out of eighteen there was less present; but this may possibly have been due to individual variation in the leaf itself, as the method of taking equal weights of leaves for examination has some drawbacks, but no better method has as yet suggested itself.

It was found that catalase, another enzyme which was discov-

¹ *Loc. cit.*

ered in connection with tobacco by Loew,¹ was present in both healthy and diseased leaves in comparatively small amounts, but that there was practically no difference in the amounts present. Twenty samples of healthy and diseased leaves were tested, and below will be found a table containing the averages of these tests. The comparative amounts present were represented by the oxygen developed from a standard solution of hydrogen peroxide, which contained 3 per cent. H_2O_2 .

TABLE II. — *Amount of Oxygen developed from Healthy and Abnormal Leaves.*

[Averages of twenty samples.]

	Number of Samples.	Amount of Oxygen developed.	Time.
Abnormal,	20	118.5	30 min.
Healthy,	20	114.0	30 min.

The samples were shaken during the test, as this has been found to increase the amount of oxygen developed.

Fifteen grams of leaves were used in each case.

Individual variations were found in most cases between leaves of different kinds, but not sufficient to warrant distinctive mention.

Thus, in respect to the amount of catalase present we find that there is a difference between this disease and mosaic, for in the case of mosaic disease there is less catalase present in the diseased leaves than in the healthy ones.²

Colorimetric tests of healthy and diseased leaves were made to determine the relative amounts of nitrates present, and it was found that in the case of diseased leaves a deeper color was obtained than in the case of healthy specimens. The test for nitrates used was the well-known diphenylamine reaction. Only approximate results were obtained, but sufficient to show that nitrates were more abundant in diseased leaves than in normal specimens. This tends to confirm the idea that this disease is more a form of malnutrition or overfeeding than a specific trouble, such as "mosaic."

Aside from the direct work on the disease it was observed in some few cases that diseased leaves were more liable to the

¹ U. S. Dept. Agr., Report No. 68.

² Mass. Agr. Exp. Sta. report, 1908.

attacks of leaf-sucking insects, such as aphids, etc., as in a few instances specimens of diseased shoots were obtained which showed the effects of these insects, and some aphides were found also. No insects were observed, however, on healthy shoots, or to so great an extent on shoots which had only a slight indication of the disease in question. It appears from our observations that the disease renders the shoot more liable to the attacks of insects on account of its weakened condition, in some respects it being far more normal; also, the attacks of insects intensify the disease by taking from the leaf a large amount of proteids and sugars. The effects of insects have been noted by various authorities, among which may be mentioned Woods¹ and Suzuki.² More specific and interesting facts on this point might be brought out by further observations and detailed study in conjunction with entomologists, but this is without the scope of the present paper. It is, however, true that insects seem to prefer a diseased leaf to a healthy one under these conditions.

More purely chemical work would undoubtedly be of great interest in connection with this interesting disease, and no doubt will find a place in a future report, but it is thought that enough has been done with the disease to bring out several new points in regard to it.

CONCLUSIONS.

(1) The abnormal condition of leaves, shown by severe distortion and increase in number, and also sometimes in size, may be classed under the malnutrition diseases, due to functional derangement; as no fungi or bacteria have been found associated with it. It must therefore be due to internal conditions, such as an abnormal metabolism.

(2) It is allied to those pathological conditions which may be brought about by excessive use of nitrates or overfeeding.

(3) It is not allied to mosaic disease, which it somewhat resembles, as this is capable of transmission from one plant to another, and in no case have we been able to bring this result about by inoculation with tissue of malformed leaves.

(4) From our observations it is not of a permanent character,

¹ U. S. Dept. Agr., Bur. Plant Ind., Bul. No. 18.

² Gen. Bul. Col. Agr., Tokyo, Vol. IV., No. 4.

as the shoot will outgrow it in from three to five years, and does not seem to suffer any serious ill effects from the trouble.

(5) It is caused by a sudden disruption of the metabolic processes of the tree, all leaf activity being suspended; and there being no normal relationship between root metabolism and leaf metabolism, the new shoot is unable to properly bring into available form the food supplied for the nourishment of the tree. In other words, there is an attempt on the part of the leaves to correlate their functions with a root area many times larger, and consequently a pathological condition is set up within the tissue, due, as has before been said, to imperfect metabolism.

PEACH AND PLUM TROUBLES.

BY RAYMOND DEAN WHITMARSH, B.S.

Many diseases of the plum and peach have been known and described for years. Standing probably first among the most serious of the fungi are "brown or fruit rot," or *Monilia* (*Sclerotinia fructigena* (Pers.) Schroet.), and scab (*Cladosporium carpophyllum*, Thümen). These fungous troubles have been very noticeable in the peach and plum orchards at the college during the past year or two.

The writer began investigations early in January, 1909, mainly to determine the cause of so much gum flow on the peach, almost every tree being affected to a greater or less extent. In connection with this study nearly every phase of the above diseases as they are described by various writers was noted, and a brief résumé of their characteristics and methods of treatment is given here, with observations on "gummosis" of the peach.

This paper has been prepared under the supervision of Dr. G. E. Stone of the Massachusetts Agricultural College, and to him I wish to express my heartiest thanks for his many suggestions, criticism of manuscript and verification of observations.

BROWN ROT OR FRUIT ROT, *MONILIA* (*Sclerotinia fructigena* (Pers.) Schroet.).

Distribution and Host Plants. — This disease is reported by Saccardo as being found in Germany, France, Austria, Italy, Belgium, Great Britain and the United States, where it is known as *Monilia fructigena*, one of the "imperfect fungi." Tubeuf and Smith speak of the disease as being very common in the United States and Great Britain. It was first described in the United States by Dr. C. H. Peck in 1881; since that time

a great many investigators have been at work on it. Finally, Prof. J. B. S. Norton in 1902 succeeded in giving us its life history in full, having found the ascospore stage. Within the United States, at least, the greatest damage is caused to the stone fruits.

Symptoms (on Fruit). — The first indications of the disease on the fruit are brown spots of a leathery appearance, which enlarge rapidly, and after the mycelium has become mature, the conidiophores break through the epidermis and give to the spots a downy, dirty, grayish-brown color, due to the great quantity of conidia produced by the fungus. The fruit then shrinks and withers to a thin, tough pellicle. In this "mummied" condition it hangs on the trees over winter or falls to the ground, where the fungus remains dormant until the right conditions of moisture and temperature cause it to become active and attack its host the following spring. The dormant or sclerotium form of this fungus occurs where the "mummied" fruit has laid on the ground over winter, covered by a thin layer of soil. These sclerotia give rise to apothecia, which are funnel-shaped, resembling small toadstools. The asci line, the cup-shaped portion of the apothecia and each ascus, contains eight ascospores. So far as I know this has not been found by any of the Massachusetts Experiment Station staff. The fungus will attack the fruit at different stages of its growth, but it makes the greatest headway on fruit that is almost mature. If the fruit has been attacked by the curculio, or injured in any way, the fungus readily takes advantage of the injury to get in its deadly work. It might be said, however, that although it attacks the fruit most readily where it has been injured, it will also attack the perfect fruit should the humidity and the temperature of the atmosphere be right. In the case of plums the fungus may have been working for some time within the tissue without being outwardly noticeable. This fact has put many shippers to great disadvantage and caused them much loss.

On Flowers. — The fungus usually first attacks the flowers just after the petals fall, but it has been known to attack them previous to that time. The first indication that the fungus is present is a slight brown discoloration on some part of the

flowers. This rapidly spreads until it affects the whole flower, and frequently extends into the pedicles. These diseased flowers often remain on the tree several weeks, until a heavy rain or damp weather comes, when they begin to fall, and as they are very sticky, owing to their decaying condition, they adhere very effectively to leaves and fruit, and serve as a new place of infection. They may remain in these new locations for some time before they are washed to the ground. When the fungus from the flower penetrates the pedicle, we have what is commonly called "twig blight."

On the Twigs. — One form in which the fungus attacks the twigs is commonly known as twig blight, and it is apparently a result of the early attacks on the blossoms. I have noticed it attacking both the peach and plum, but more often the former. The fungus penetrates the pedicle and into the tissues of the twig, causing a flow of gum. This fungus often works around the entire stem, cutting off all source of nourishment from the distal portion of the twig, causing it to die. The gummy portions and girdling resemble quite closely the symptoms of another disease, known as canker. In summer and early fall, as well as in spring, we often find this blighting of twigs, the source of infection being the fungus from the decaying fruit. This bores through the pedicle and then ramifies through the stem, often girdling it, as in the case of the blight, where the source of infection was the flowers. The injury in both cases nearly always is confined to a point near the attachment of the fruit or flowers. When the girdling is complete the leaves beyond the point of attack dry up and die.

Another form in which I have noticed it might be called the "brown spotting of twigs." This phase of the disease has been described by Dr. G. E. Stone of the Massachusetts Agricultural College. The spotting occurs on the new shoots, and was not noticed except in the case of the peach. These spots may be single, or several may come together, forming a more or less irregular mass. In these spots we find *Monilia*, which presents similar characteristics to the one found on the fruit. The principal distinction between this and the common *Monilia* of the fruit consists in the smaller spores of the former. Numerous

cultures and comparisons made of the two types of *Monilia* — that on the fruit and on the stem, made by Dr. Stone — show that the spores of the one on the twig are always smaller when grown in any media than those of that on the fruit, and the two species react quite differently chemically when grown in solutions on different media.¹

On the Leaves. — In wet weather, especially, one often notices spots on the leaves. These are found on both the upper and lower surfaces, but are generally most conspicuous on the upper. During wet, warm weather, if one examines these spots carefully he will find here and there small grayish masses of powder, which are in reality the conidia of the “brown rot” fungus.

Spores. — The spores, more or less oval shaped, are one celled, and their contents are quite noticeably granular. These spores germinate readily in water, producing a mycelium whose contents are granular, as in the case of the spores. The mycelium is broken up here and there by cross walls. The spores are produced in chains by a sort of budding, the last one of the chain being the newest one. When grown on culture media (prune agar) these spores form much longer chains than on the fruits out of doors.

Means of Spore Dispersal. — The influencing factors in the spreading of this fungous disease are wind, rain, insects (especially plum curculio), etc. Many minor ways in which the spores are disseminated might be enumerated, but the three above-named methods are probably by far the most influencing.

Methods of Control. — I would suggest the following ways in which to lessen the attacks of this disease. Destroy all “mummied” fruit which hangs on the trees or has fallen to the ground. Cut off and burn all twigs that are infected with the fungus mycelium. Keep the trees pruned, so that there will be a free circulation of air and plenty of light, because a tree which is crowded with cross limbs and has in consequence too much foliage acts as a convenient forcing house for “brown

¹ Dr. Stone has observed this species on the twig for many years in Massachusetts, the twig sometimes being very badly spotted. *Monilia* is also sometimes associated with *Cladosporium*, but the *Monilia* by far predominates. Where lime and sulphur has been used as a spring spray these spots have been entirely absent, with a much better annual growth of the twig as a result. (See Nineteenth Annual Report, Massachusetts Agricultural Experiment Station, p. 166.)

rot." Thin the fruits so that they do not at least come in contact with one another. By using the above precautions and applying the following spray mixtures for "brown rot," "scab" and "plum curculio" I believe that the fungus can be almost entirely controlled. For the Elberta, Belle, Reeves, and other varieties of peaches of about the same ripening season, the following is advised: (1) about the time the calyces of shucks are shedding, spray with arsenate of lead at the rate of 2 pounds to 50 gallons of water. In order to reduce the caustic properties of the poison, add milk of lime made from slaking 2 pounds of stone lime. The date of this treatment is too early for scab, and ordinarily no serious outbreaks of brown rot occur so early, so that the lime sulphur may be omitted with reasonable safety; but during warm, rainy springs, especially in the south, the lime sulphur will doubtless be necessary in this application. (2) Two or three weeks later, or about one month after the petals drop, spray with self-boiled lime sulphur; 8 pounds of lime, 8 pounds of sulphur and 2 pounds of arsenate of lead to each 50 gallons of water. (3) About a month before the fruit ripens, spray with the self-boiled lime sulphur, omitting the poison.

For earlier maturing varieties, such as Waddell, Carmen and Hiley, the first two treatments outlined above would probably be sufficient ordinarily, but in very wet seasons varieties susceptible to rot would doubtless require three treatments. Late varieties, such as Smock and Salway, having a longer season, would not be thoroughly protected by three applications. In view of the results obtained on midseason varieties it seems likely that three treatments will ordinarily be sufficient for the late varieties.

BLACK SPOT OR SCAB (*Cladosporium carpophyllum*, Thüm.).

History and Distribution. — This fungus was first noticed in 1876 by Von Thümen of Austria, who was at that time botanist to the Austrian Experiment Station. In the year following, 1877, he described the fungus, giving it the above name. Since that time it has been met with quite commonly in this country. In Saccardo's "Sylloge Fungorum" we find a copy of Von

Thümen's description, which mentions only that it was found in the locality of Klosternenburg, where the Austrian Experiment Station was located.

On the Fruit. — Small, round, blackish spots on the skin of the fruit are the first indications of the disease. These spots usually appear when the fruit is about two-thirds grown, most frequently on the upper side of the fruit, and if the spots are very numerous they will, as they grow, coalesce and form a large, irregular, diseased area. When the fruit is thus attacked it becomes one-sided, due to the fact that a corky layer of cells is formed by the fruit under the diseased area as a protective layer. This corky layer is incapable of further growth, and hence we get, as a result, the ill-formed fruit. The corky layers are often ruptured, leaving deep cracks, which furnish an ideal place for the growth of the spores of *Monilia*, which are always ready to take advantage of such injuries. Hence we often find both troubles on the same specimen. This disease attacks the fruit much in the same way as the scab of apple and pear. Its attacks are generally most noticeable on the late varieties of fruits, and it thrives most luxuriantly during damp weather.

On the Leaves. — This fungus causes a shot hole appearance of the leaves. The first indications one has of the disease upon the leaves are scattering brown spots. These spots, as a rule, spread over the leaf, and as the fungus matures the tissues dry up and the diseased portion falls out, leaving a circular opening. This fungus seems to prefer the part of the leaf between the veins. The spores of the fungus attacking the leaf agree with those growing on the fruit, with the possible exception that they are somewhat smaller, but no doubt this slight variation is due to the environment rather than being a specific character.

On the Twigs. — Sturgis gives an account of this fungus attacking the peach twigs. He states that the twigs are marked more or less abundantly with circular spots, somewhat resembling in appearance the "birds' eye rot" of grapes (*Spaceloma ampelinum*, DeBary). Frequently the spots join together and cover the twig so thoroughly as to destroy the pinkish-brown color of the bark. Although not having seen this phase of the

disease, it apparently resembles in outward appearance very much the spotting that I described as due to the brown rot fungus.¹

PEACH LEAF CURL (*Exoascus deformans* (Berk.) Fuckel).

This disease is found commonly in Massachusetts, and, as a matter of fact, more inquiries are sent to the station in regard to this trouble than any other peach disease. It is found in almost all parts of the world where the peach is grown to any extent, and has been seen by the writer in great quantities in the large orchards along the shores of Lake Erie.

It attacks the leaf buds just as they begin to open in the spring, also the tender shoots, flowers and young fruit, but is not so noticeable as on the leaves. The leaves become very much swollen, wrinkled and curled, and a little later take on the appearance of a moldy gray covering. In the earlier stages of the disease the leaves often show red or pinkish blotches, but they turn a brownish color as they grow older and fall to the ground. Cold and damp, or rainy, weather in the spring greatly favors this disease, and in fact determines the degree of severity of the attack. It often defoliates the trees to such an extent that they are not able to lay up sufficient material for their needs, or ripen the wood properly, so that when winter comes the trees are often found to be much weakened. In some cases the disease has been so severe that the trees were not able to endure the cold of winter, and consequently were winter killed.

It was previously thought that infection took place only by perennial mycelia, but this theory has gradually been discarded. Infection may take place by perennial mycelia, but most writers and observers now agree that infection is due almost entirely to the spores, which live over winter on the bark of trees and in other places.

The Elberta peach is one of the most susceptible varieties to the attacks of this fungus, but all varieties seem to be more or

¹ For other points of interest in regard to the fungus not given in this paper see Arthur's and Chester's writings.

less subject to the disease. Trees injured by other agencies, and consequently weakened, seem to be more susceptible to attack than healthy, vigorous trees.

It will be readily seen that it is probably useless to spray the trees after the leaves become infected, but since the spores live over winter on the bark, the trees should be sprayed in the spring, while the spores are still dormant.

It is generally accepted by all the largest and best growers that the lime sulphur wash, used for the control of San José scale, is by far the best remedy for this trouble, although some prefer Bordeaux and others copper sulphate solution, where the scale is not present. Since there is nearly always danger from scale infestation, however, it seems wiser to use the lime and sulphur, which is undoubtedly of great fungicidal value, as well as one of the best remedies for the scale.

The spray should be applied to the trees from one to two weeks before the buds open, if possible on a quiet day when the atmosphere is free from moisture.

If the above directions are followed, this treatment should suffice for the leaf curl and the San José scale. For this spray mixture use 10 pounds of good fresh stone lime and 15 pounds of sulphur to each 50 gallons of water. Make up the above spray solution as recommended by Quaintance.

Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot, add all the lime and at once add all the sulphur, which previously should have been made into a thick paste with water. After the lime has slaked, about another third of the water should be added, preferably hot, and the cooking should be continued for one hour, when the final dilution may be made, using either hot or cold water, as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by steam, no stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray pump or tank. The wash may be cooked in large kettles, or, preferably, by steam in barrels or tanks.

PLUM POCKETS (*Exoascus Pruni*, Fuckel).

The organism causing the disease known as "plum pockets" is closely related to that causing peach leaf curl, although not occurring on the peach. It was previously thought that the source of infection was only through the hibernating mycelium in the twigs and branches, but from what can be learned in regard to this more investigation seems to be needed on this point. A short time after the young fruit forms, it becomes yellowish, much swollen and stoneless.

These hollow, dropsical-like plums are often streaked with red at first, but after a time they take on a moldy, grayish appearance, similar to the peach leaf curl, and soon fall to the ground. This moldy covering is composed of sacs (asci) which contain the spores.

The attacks of this parasite are generally local, possibly only one tree in a large orchard being affected, and the treatment given for peach leaf curl would probably suffice here.

BLACK KNOT (*Plowrightia morbosa* (Schw.) Sacc.).

One often notices in small family orchards containing a variety of trees, where little care is given them, that some of the plum trees show signs of a disease known as black knot. The knots often extend entirely around the limbs, and as a consequence the more distal parts of the limbs receive but little nourishment, and finally die.

Black knot, if given no treatment, usually destroys the value of the tree within a year or two, even if it does not kill the tree in that time. Almost all varieties of plums are subject to this disease. The first noticeable indication of the disease in the spring is the enlargement of limbs and branches affected. The bark then breaks open, and this new surface soon becomes covered with a moldy, green-like substance which contains the spores. This is followed by black knots containing spores which become mature before the next spring. The spores evidently obtain a foothold on their host through cracks or injuries caused by various agencies. It is therefore essential in the care

of an orchard that one should be careful not to bruise or injure the trees.

The wind is probably the greatest agent for conveying the spores from tree to tree. Remedial measures consist in pruning off the knots and burning, and it has been advised that they be cut out when young, and the exposed area coated with paint. Observations and experiments have shown that early spring spraying materially lessens the infection.

PLUM LEAF SPOT OR SHOT HOLE (*Cylindrosporium Padi*, Karst).

This disease causes spots on the leaves somewhat circular in outline, which often become joined. These affected parts usually have a reddish outline, and finally the diseased tissue turns dark brown and falls out. The leaves turn a yellowish color and often begin to fall in July, but the most severe defoliation usually occurs in August and early in September. The great loss from this disease is caused by defoliation before the tree stores up sufficient starch and ripens its wood enough to enable it to stand the cold of winter. Continual attacks very much weaken the tree and eventually kill it, but if lime sulphur is used thoroughly, little trouble will be experienced from this disease. This same disease also affects the cherry.

PEACH SHOT HOLE (*Cercospora circumscissa*, Sacc.).

The effects of this disease resemble those caused by *Cylindrosporium* of the plum. The diseased spots fall out, and the small branches are also attacked, often causing a great number of the young shoots to die. Spray with lime sulphur, as for peach leaf curl.

Shot Hole Effect caused by improperly mixed Bordeaux.

When improperly mixed Bordeaux is used for a summer spray, we invariably find the leaves badly riddled with holes, due to the burning of the tissues. One can readily distinguish this type of shot hole from those previously described, for the leaves which come out on the new shoots remain unaffected,

whereas, if the trouble had been due to a fungus, the new leaves would also become affected. Bordeaux is not, therefore, always safe to use on mature foliage, even at reduced strengths, for it has often been known to cause trouble when used at only half strength.

GUMMOSIS OF THE PEACH.

For the past two years there has been an abundance of gum flow in the college peach orchard. This has been found to the greatest extent on the early varieties, and owing to the poor condition of many of the trees it has seemed best to destroy them. The following gum disease which I am about to describe resembles almost identically in most of its life history the gummosis of *Prunus Japonica*, described by Masseé as due to *Cladosporium epiphyllum*, Fr. In this case (gummosis of peach) I believe the species to be *Cladosporium carpophyllum*, Thüm. Masseé mentions in his paper a species of *Macrosporium* that is often found in connection with this gum flow, but he is unable to find any genetic connection between the two fungi. Instead of finding a *Macrosporium* fungus in connection with the gummosis of peach, I have, with very few exceptions, found a species of *Alternaria*¹ or *Alternaria* form, which is apparently something new, as the fungus, in addition to the ordinary alternaria spores, bears pycnidia bodies containing many minute hyaline spores. These in turn give rise to *Alternaria* spores and more pycnidia. I could not, however, establish any genetic connection between this form of *Alternaria* and the *Cladosporium*.

Probable Cause of Gummosis.

On the trunks and large branches the gum flow is evidently due to borers, frost cracks and sun scald, and a copious flow of gum at any place of injury is generally found. These places serve as a refuge for the spores of *Cladosporium* and *Alternaria*, and we find some form of *Penicillium* inhabiting the same mass. But whatever the original cause of the flow, it is certain that these forms of *Cladosporium* and *Alternaria* take a hand in

¹ The organism which we term *Alternaria* here may possibly be an undeveloped form of some other type, such as *Pleospora*, etc.

stimulating the host to a more abundant flow. The mycelium of these fungi penetrate every portion of the gum, and their fungous threads may be seen even penetrating the host itself.

On the Fruit-bearing Wood.

The gum flow is almost without exception found at the base of the pedicle bearing diseased fruit. These gummy masses may be confined to a small area in the region of the pedicle, or may extend some little distance below and above the pedicle, sometimes becoming so bad as to entirely girdle the branch, thus killing the entire distal portion. When this happens it is best to cut the diseased member off some two or three inches below the gummy area. I believe this gum flow is first caused on these small branches by the brown rot fungus, which is, without an exception, found on the fruit attached to the diseased pedicle. But as soon as this fungus causes the flow of gum the *Cladosporium* and *Alternaria* come in, as in the case of the injuries on the trunks and large branches. After the above fungi, *Cladosporium* and *Alternaria*, get a foothold, it would seem that the brown rot fungus is less noticeable. *Monilia* is often to be found in these gummy masses, but in masses containing *Cladosporium* and *Alternaria* this fungus has been found very sparingly. These masses become soft during the damp spring weather, and are usually washed to the ground by rains.

Appearance of Cladosporium and Alternaria under the Above Environment.

At first the gummy mass is light in color, but after it remains on the tree some time it becomes browned and blackened. On sectioning one of these masses it is found that the darkened area is near the surface, due to the formation of dark, thick-walled cells, while farther in the mycelium becomes gradually lighter in color, until nearly colorless at the center. On inoculating branches of peach trees with the conidial form of *Cladosporium* grown on prune agar it was found that some little time afterwards a greenish growth of *Cladosporium* appeared. After the spores had disappeared there soon appeared small, tear-like drops, which, as the season advanced, grew larger and darker



Showing a Cross-section of a Three-year-old Peach Twig affected with
"Gummosis."

in color. On examination in the fall these masses were found to contain mycelium and spores similar to those found in other gummy masses in the orchard. These chains of dark spores produce many thick-walled spores, or micro-sclerotia, as described by Masseé, and these thick-walled spores, or micro-sclerotia, in turn give rise to many small hyaline conidia, while another form of the micro-sclerotia gives rise to a mycelium which bears numerous conidia. In the gummy mass one finds present many pycnidia of a brown color, similar in color to the micro-sclerotia, and from their situation, color, etc., one would take them for different stages of the same fungus. However, on isolating these pycnidial bodies, which were filled with myriads of minute hyaline spores, and growing them on pure cultures, I was unable to get any connection between the two; but I found that the minute hyaline spores without exception gave rise to other pycnidia and *Alternaria* spores; the *Alternaria* spores, growing on the same mycelium as the pycnidia, in turn gave rise to pycnidia and *Alternaria* spores.

Histological Changes Accompanying Gummosis.

The cut facing this page represents a cross-section of a diseased twig of a peach tree, showing two well-developed annular rings and a third partly developed. This twig was probably attacked by the brown rot fungus, together with *Cladosporium* and a form of *Alternaria*.

This section, which is a typical one, shows that the disease did not destroy the cambium ring until the fall of the second year, but the disease may have made its appearance even a year earlier. The noticeable feature in this illustration is that the last layer of wood formed was very much thinner towards the uninjured side of the twig than the injured side, and this ring of wood is not complete near the area where gummosis had set in. There is also a noticeable thickening of the incomplete rings of wood near the point of injury, a fact due probably to the difference in tension occurring in the stem produced by the injury from gummosis. The cambium, at the margin of the diseased area where it has attempted to heal over, is also much

thicker than at the opposite side of the twig, where the tension is different.

Microscopical examinations of sections also showed that considerable healing of the wound caused by gummosis took place. The callus forming as a result of this healing developed ridges along the side of the wound. The cavity of the wound was entirely filled with gum, which contained *Cladosporium* and a form of *Alternaria*.

Suggestions in Regard to the Treatment of Gummosis.

In very bad cases of gummosis it would be best to destroy the tree, since it is of little value and may possibly furnish an ideal place for the development of undesirable organisms. Branches may be cut off a few inches below the affected areas. Since this disease undoubtedly originates from the practice of leaving "mummied" fruit attached to the tree, it is best to remove and destroy them. It is even a question whether "mummied" fruit should be left on the ground. Practically all cases of infection from gummosis have occurred where the "mummied" fruit was left on the tree, and came in contact with the limb or branch.

Care should also be exercised in pruning, and this should be done in winter or early spring. A clean, sloping cut should be made, and large wounds should be covered with paint or coal-tar. This treatment will prevent infection from the wounds.

The practice of good sanitation and systematic spraying of peach trees, together with cultivation and feeding, will undoubtedly hold this disease in check.

DIRECTIONS FOR MAKING SUMMER SPRAY MIXTURE.

Essentials.

In making the self-boiled lime sulphur plus arsenate of lead, as recommended for the summer sprayings, the first essentials are to have good stone lime, a perfect mixture of the ingredients, and two men to attend to the mixing. After being mixed it is necessary that the mixture be kept well agitated while in the tank, for if not it will settle, no matter how well made. To

accomplish this it is suggested that those using a power outfit employ an agitator of the propellor type, as most others will allow a little settling; and where this occurs an even mixture of the spraying materials is not obtained.

Directions.

The following method has been found to work out satisfactorily in making 250-gallon quantities. First, weigh out 40 pounds each of good stone lime and flour of sulphur. Take the above quantity of lime and place in the bottom of a barrel (one holding 50 gallons is a convenient size to use when not making over 300 gallons at a time); then pour on water slowly and evenly. A good way to do this is to use a fine spray from a nozzle. As soon as the lime begins to slake have the sulphur sifted over the lime, adding just enough water while doing this to keep the lime from burning. By the time the sulphur is added the lime has become very active, and requires one person's attention to stir the mixture while another adds the water just fast enough to keep the mixture from burning. Water should be added cautiously to obtain the best results in slaking.

If the above directions are followed there will first be a thick, pasty substance which gradually becomes thinner as more water is added. The lime ought to keep the mixture well heated for several minutes, but as soon as it becomes well slaked water should be added. If allowed to cook too long the sulphur will go into solution and combine with the lime to form sulphides, and this form is harmful to the foliage. Weigh out 10 pounds of arsenate of lead, add water, and stir until thoroughly mixed; then strain through a sieve (20 to 30 mesh to an inch is satisfactory) either into the spray tank or barrel containing the lime-sulphur mixture. On the addition of the arsenate of lead to the lime sulphur, a dark-colored mixture is obtained. If the mixture has been properly made there will be very few settlings, and very little, if any, sulphur floating on the surface. The ingredients of this mixture ought not to settle for nearly half an hour. The above mixture should be strained into the spray tank and the tank filled with water. The solution is then ready to be sprayed on the trees.

CONCENTRATED LIME-SULPHUR SOLUTION.

The inconvenience experienced in preparing the lime-sulphur wash by cooking with steam or in open kettles at home has been one of the principal objections to this spray. Certain manufacturers have therefore put on the market concentrated solutions of lime-sulphur wash which have only to be diluted with water for use. These commercial washes have proved to be about as effective in controlling the scale as the well-cooked lime-sulphur wash, and, although somewhat more expensive, have been adopted by many commercial orchardists in preference to the home-prepared spray. They are especially useful for the smaller orchardist, whose interests do not warrant the construction of a cooking plant. In other ways, too, they possess advantages; for instance, those using the commercial washes may always have on hand a stock solution, so that the spray may be quickly prepared and advantage taken of favorable weather conditions. These preparations should usually be used at the rate of 1 gallon to 10 gallons of water.

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CLIMATIC ADAPTATIONS OF APPLE VARIETIES.

BY J. K. SHAW.

I. INTRODUCTION.

The conditions of soil, climate and culture under which our many varieties of fruit succeed are little understood. Most of the publications dealing with varieties concern themselves with histories and technical descriptions, and but very little with the conditions under which the planting of this or that variety is to be recommended. As a result of this lack of information a given variety is planted under widely varying conditions, under some of which it does well and under others it does poorly.

At the present time fruit growing, more especially the growing of apples, is entering a new era. The increased demand resulting from the lessened production during the past decade; improved methods of culture, especially a better understanding of the combating of insects and diseases, and better business methods have stirred up growers all over the apple regions to a renewed interest in the business. This movement has had its origin in the Pacific coast and intermountain regions, but will soon, if it has not already, become general over a large portion of North America.

This movement will result in more or less change in the relative importance of commercial varieties, some becoming less esteemed and others gaining in favor. The consumer will come to prefer varieties of better quality and those better suited to various purposes. The same is true within a variety, where specimens grown to more perfect development will receive preference.

To attain the highest degree of success it will be more necessary than in the past for each grower to choose those varieties which he can grow, under his conditions of soil and climate, to

their highest perfection. A mistaken choice will be a serious thing, and one that will require valuable time and much expense to correct.

The present paper is the result of a study, carried on for the past four years, of the effect of varying climatic conditions on varieties, and an attempt is here made to lay down certain principles as to the climatic adaptations of varieties. Questions of soil and culture are given only incidental consideration. For the former there has not been sufficient opportunity, and a consideration of the latter would lead into the whole field of orchard management. Many samples of different varieties, grown under widely varying conditions, have been examined pomologically, and some of them chemically, and a study made of the pomological and meteorological literature available.

This paper does not make specific recommendations of varieties for any section of the country or for the country in general. That is more or less a local problem into which enter questions not considered here. Among them are those of soil, market demands, methods of culture to be followed, the individual preferences of the grower and many others. If the conclusions of this paper are sound, they should aid in such choice, for many varieties that might otherwise be considered are excluded as not being suited to the climatic conditions of the locality under consideration, while from those that are adapted climatically, the ones best suited to soil and other conditions may be singled out.

The subject under consideration is a large one. To understand at all fully the relations of apple variation to climate will require prolonged study and experiment. This paper is, in a large degree, introductory, and may contain errors and omissions which should be corrected. The writer will greatly appreciate any suggestions as to corrections or additions that should be made.

The work has been done as Adams fund research, and at the same time in partial fulfillment of the requirements for the degree of Doctor of Philosophy from the Massachusetts Agricultural College. It has been done under the direction of Prof. F. C. Sears, to whom the thanks of the writer are extended for

advice and criticism, and to Prof. F. A. Waugh as well, who has given many helpful suggestions. The chemical work has been under the direction of Dr. Charles Wellington, and assistance in the analytical work has been rendered by Mr. E. L. Winn and Mr. B. Ostrolenk of the senior class in the college. Many experiment station horticulturists and fruit growers in many sections of the country have aided by giving information and by furnishing samples of apples. It is impossible to name them all here, but their many favors are here acknowledged and hearty appreciation extended.

II. THE CAUSES OF VARIETAL VARIATION.

The causes of the great differences in apple varieties may be grouped under three heads: those arising from (1) cultural conditions, (2) differences in soil types, (3) differences in climate.

CULTURAL VARIATIONS.

The methods pursued in the growing and in the care of the trees have great influence on the character of the fruit. It is affected in every way, in size, form, color, keeping quality, shipping quality and dessert quality. These variations have been given only incidental investigation of such phases as relate directly to the climatic differences that have been the special object of study. A few of these may, however, be given passing attention at this point.

Every orchardist growing any number of trees is aware that there are great differences in the individuality of the trees, even when grown in the same orchard and under apparently identical conditions of climate and soil. One tree may be very productive and its neighbor only moderately so. The apples may differ in many of their characters. Further along in this paper some data are presented bearing on this question (see page 194). These individual differences have been ascribed to various causes, the principal ones of which are, perhaps, those of bud variations or varietal "strains," and that of the influence of the stock.

The method of handling the soil has great influence on the fruit, especially whether the orchard is in sod or is cultivated.

This has been shown in various bulletins from different experiment stations. The Baldwin seems especially influenced by conditions of orchard culture, and other varieties more or less so.

Certain experiments at this station ¹ have shown marked effects from the use of different fertilizers. This question has been little investigated, but no doubt great variation in fruit may be produced by the fertilizer used on the land. Differences in pruning also have their effects. A tree kept with an open top will admit an abundance of sunshine, resulting in a higher colored fruit; in many other ways the effect of pruning may be shown in the character of the fruit.

Many fruit growers have discovered, to their grief, that Bordeaux mixture has a decided effect on many varieties, by producing russeting. On the other hand, the lime-sulphur preparation has frequently been found to render the appearance of the fruit better than when not sprayed at all.

SOIL VARIATION.

It has been shown that the nature of the soil has great effect on the character of the fruit. Red apples are likely to be higher colored on sandy soils than on clayey soils. Not enough is known regarding this question to make any very definite generalizations on the subject. H. J. Wilder has determined the soil adaptations of various varieties, and shown that different varieties have decided preferences as to soils.² The question of the adaptation of varieties to soils is much complicated by the question of stocks already alluded to. No doubt varieties have soil preferences which are general to the variety, and not seriously modified by differences in stock. Nevertheless, the writer is satisfied that much greater uniformity would be found in the adaptation of varieties to soils were they grown on their own roots.

CLIMATIC VARIATION.

In a broad way, the limits of apple growing are governed by climatic conditions. The apple is a fruit of a temperate climate, and does not flourish in the far north nor in the warmer

¹ Report, Massachusetts Experiment Station, 22, Part II., p. 10.

² Proceedings American Pomological Society, 31, p. 138 (1909).

sections of the temperate zones. The apple adapts itself under cultivation to a considerable range of rainfall, and in districts of deficient precipitation irrigation is practiced. Therefore, the question of rainfall has comparatively little weight in the general cultivation of the apple. Sunshine has considerable effect, but it is not a limiting factor anywhere in the apple belt. The great climatic factor which limits the distribution of apples in general, and of the different varieties in particular, is temperature.

Over the greater part of the North American continent the northern limit of successful apple growing is fixed by the minimum winter temperature. Different varieties of the common apple vary greatly in their ability to withstand minimum winter temperatures, and the condition of the tree, particularly as regards moisture content at the time minimum temperatures occur, has great influence in determining whether the tree survives. Very few, if any, varieties will withstand a temperature much below -40° F. without being killed back more or less. In many cases a considerably less severe temperature is fatal to even the hardiest varieties. With the possible exception of the extreme northern Pacific coast, under conditions of a maritime climate, there is nowhere in North America a region where certain varieties will not produce fruit in summer, provided they can withstand the cold of winter. In other words, the summers are warm enough to mature fruit of short-season varieties, provided the winters do not kill the tree before it has reached the bearing age.

The apple does not succeed in the southern portions of North America, although fruit may be produced in every State of the Union, and probably in portions of Mexico. The difficulty in the way of the southern extension of apple growing seems to be largely the heat during the summer. The trees fail to grow during hot periods in the growing season, and fail to set, or at least to mature fruit. The latter is especially true of winter sorts, and many varieties grown in the south are short-season ones, which are able to mature fruit before the hot periods of July and August arrive.

The Mean Summer Temperature.

For this work we have used as a measure of the summer heat an average monthly mean for the growing season. This has been taken as comprising the months of March to September inclusive. The monthly means for these seven months, as given in publications of the United States Weather Bureau and Canadian Meteorological Service, are averaged. This gives, for points within the apple-growing regions of North America, temperatures varying from about 52° to about 70° or 72° . Summer means have been computed for a great number of stations, and from these the isotherms given in Fig. 16 are drawn. This map is intended principally for study in connection with the matter given later in this paper, but it may be proper to explain it at this point, and to discuss the variations in the summer mean that occur and the causes thereof. In common with other questions of temperature, the summer mean for a given section is determined by a number of considerations. Among these are the following: (1) latitude, (2) elevation, (3) site and aspect, (4) soil, (5) culture, (6) prevailing winds, (7) sunshine.

The first two require no explanation. Temperatures vary inversely with the latitude and altitude, but, owing to the influence of the other features mentioned, no ratio can be laid down that is of any value.

With regard to slope, little need be said. The summer mean on a north slope may be several degrees lower than that of a corresponding southerly slope, though we have been unable to find any data showing the amount of difference. Slope must be considered in estimating the probable temperature of an orchard site.

Soils containing a large proportion of sand will not only be warmer than clayey soils, but will also influence the air temperature in the orchard to a considerable degree.

Hedrick found that the soil in a tilled orchard was from 1.1° to 2.3° warmer than a corresponding plat in sod.¹ This must have an influence on the air temperature in the orchard.

Prevailing winds influence the summer mean. These are de-

¹ Bulletin 314, New York Experiment Station.

terminated by mountain ranges and other topographic features, by the temperatures of bodies of water over which the air may have passed, and perhaps by other considerations.

The prevalence of a large proportion of sunshine will operate to raise the temperature in the orchard. The effect on the protoplasm of the tree will, owing to the heat absorptive powers of the dark colored bark, be even greater. This has been shown by Whitten. He also found that in peaches the color of the bark modifies in a marked manner the thermal effect of the sun.¹ The temperatures on which this work is based were presumably all taken in the regulation shelters of the Weather Bureau, where this effect would be less than in the orchard. The probable amount of sunshine should be taken into consideration in estimating the summer mean of an orchard.

III. THE DEVELOPMENT OF THE APPLE.

For convenience in discussion, the life history of the apple (fruit) may be somewhat arbitrarily divided into four periods: (1) that of growth, which extends from the blossom to the attainment of full size; (2) that of ripening, which covers the period from the termination of the first until the apple is picked from the tree; (3) that of "after ripening," extending from picking until the apple is in perfect eating condition; and (4) that of decay, covering the subsequent deterioration and breaking down of the fruit. Various fungous diseases may enter in during these periods and terminate the life of the apple at any time. These are not considered in this discussion. The second and third periods are scarcely differentiated in summer apples, these being ordinarily fit for immediate consumption on picking. In winter apples, on the other hand, there is a distinct period of ripening following the picking of the fruit.

Inasmuch as the discussion of these periods of growth will be largely from a chemical standpoint, it may be well to consider briefly the chemical composition of apples before discussing their development.

Apples vary widely in chemical composition, according to variety, stage of development and conditions of growth. They

¹ Report American Pomological Society, 26, p. 47 (1900).

contain ordinarily from 80 to 88 per cent. of water, most winter varieties when maturing averaging perhaps about 84 per cent., the remainder of the fruit comprising the total solids. The solids consist of the following substances: first, starch, of which there may be 3 or 4 per cent., in growing apples; second, sugars, of which there may be from 5 to 12 per cent., averaging perhaps 8 or 10 per cent. The total sugars are made up of at least three distinct compounds: sucrose, of which we may find from none to 6 per cent.; and a mixture of dextrose and levulose, of which there may be from 5 to 10 per cent. These two latter sugars are separated in the laboratory with some difficulty, and comparatively few figures are available to show their relative proportions, but it is evident that the levulose in apples is in excess of the dextrose, a condition not usually found in plant substances where these two sugars occur together. Of organic acid we may find from .12 to 1.50 per cent., presumably as some form of malic acid.

The foregoing solids are all soluble in water. The insoluble solids are largely of a carbohydrate nature, and consist of cellulose and pentosans for the most part. In the chemical work reported in this paper determinations of the total insoluble dry matter have been made and given as insoluble solids, and consist of those portions of the apple not dissolved by hot water under the conditions prescribed in the method of the Official Association of Agricultural Chemists.¹

Apples, particularly in the green state, contain small amounts of tannin. In the work here reported no determinations of this have been made, but a few analyses are available from other sources, giving the percentage present. The characteristic flavor and aroma of apples are due for the most part to certain esters or flavoring oils. These exist in the apple in very minute quantities, and though they are of great importance in determining the value and quality of the fruit, no attempt to determine the amount has ever been made, so far as the knowledge of the writer goes. Indeed, it is probable that, owing to the minute quantities present, their determination would be extremely dif-

¹ United States Department of Agriculture, Bureau of Chemistry, Bulletin 107, revised.

ficult, if not absolutely impossible. We can judge of their presence and abundance only by the taste and the aroma of the fruit.

Returning now to a consideration of the changes in the fruit during the four periods of development already mentioned, we find them taking place somewhat as follows. During the period of growth the amount of total solids of course increases greatly. This increase may continue into the ripening period, but after that there is a relative loss of total solids. The percentage, also, of total solids increases during the period of growth and during at least a part of the ripening period, but after that its changes are much dependent upon conditions. The percentage of acid in the fruit is largest in the early stages of growth, and decreases more or less steadily during the entire history of the fruit. The percentage of starch increases during the early part of the growth, and at varying points, under different conditions, it begins to decrease, and disappears during the ripening process. The sucrose increases pretty steadily until the period of after ripening is complete, and then more or less rapidly decreases, and frequently entirely disappears in the process of decay. The point of maximum of sucrose content may be taken as the point of full maturity of the fruit, with a fair degree of accuracy in most cases. The reducing sugars, dextrose and levulose, increase during the period of growth, and may or may not increase slightly during ripening. In the later periods of ripening and decay they in most cases tend to increase, at least until the final stages of decay.

Comparatively little can be said regarding the behavior of the insoluble solids during the periods of growth and ripening. During the periods of after ripening and decay they pretty steadily decrease. Probably they are at their maximum during the early stages of ripening. The stage of development of the insoluble solids of the apple is of great account in determining the quality and condition of the fruit; they compose for the most part the cell walls of the fruit. During the later stages of development of the fruit the middle lamellæ of the cell walls seem to soften, perhaps through the action of some enzym. This

results in a comparatively easy separation of the individual cells from each other and in the mealy taste found in the over-ripe apple.¹

Comparatively little is known of the behavior of the flavoring oils, but it is evident that they do not develop very noticeably until the period of ripening. It would seem, however, that they develop during the later stages of the ripening period and through the period of after ripening, and tend to disappear as the stage of decay progresses.

Little, also, is known regarding the behavior of the tannin of the fruit, but it is probably highest during the late stages of growth. It may be connected with the development of color in red apples, and inasmuch as it seems to disappear during the ripening stage, when the apple is taking on color, it may be that it contributes in some way to the formation of pigment in the epidermal cells of the fruit.

IV. THE PERFECTLY DEVELOPED APPLE.

In the course of investigation herein reported, the writer has made a somewhat careful study of some twenty varieties of apples, chosen from among the more prominent and widely distributed sorts. From five to fifty or more samples of each variety have been received from many different localities scattered over the entire apple-producing portions of North America. These apples have been carefully examined and their characteristics noted, and from two to twenty samples of each variety have been subjected to chemical examination. In the case of the Ben Davis variety, during the past four years nearly two hundred samples have been received, and fifty or more of these have been given a more or less complete chemical examination. These samples have varied widely in physical appearance and chemical composition. These variations are dealt with in a later division of this paper. The study of these varieties, added to other general observations, has enabled the writer to form a fairly definite conception of them, when developed to their highest perfection in appearance, quality and chemical composition. The point of perfect development is taken as that where

¹ Bureau of Chemistry, Bulletin 94, p. 92.

the after-ripening stage is complete and before any signs of deterioration appear. A variety in this condition is at the point of highest dessert quality. Especial consideration will be given in this discussion to the question of high quality in each variety.

Before entering into this discussion, it may be well to consider the relation between chemical composition and quality. In the first place, it may be said that quality is used with several different meanings. It may refer to the dessert quality of the fruit or to its value for kitchen purposes. The apple of high dessert quality is different from the apple of high kitchen quality. We also speak of the shipping quality of fruit, and high shipping quality is in a measure opposed to high kitchen, and even more to high dessert quality. The apple which ships well will usually be a fair keeper, but these two qualities are by no means coincident. The chemical determinations which throw the most light on quality are those of the sugars and acid and of the insoluble solids, the latter being of greater importance than is usually considered to be the case.

The apple of high dessert quality is low in its content of insoluble solids, this signifying a tender flesh and probably thin-walled cells. It is high in sugars, more particularly sucrose. The amount of acid is proportional to the quantity of sugars; the higher the content of sugars the higher must be the content of acid, in order to bring an agreeable blending of these two constituents. If a large proportion of the sugars is sucrose, the proportion of acid needs to be larger than if the proportion of sucrose is low, in order to give the same quality. The ratio of acid to total sugars most favorable to high dessert quality will vary greatly with individual tastes. Some prefer a sweet apple, and, on the other hand, many like a fairly acid fruit. If the sugars are in the proportion approximately of two-thirds reducing sugars to one-third sucrose, the following may be taken as a fair estimate of the varying ratio of total sugars to acid for different flavored fruits. These ratios will not hold for fruits that have entered into the stage of physiological decay.

	Total Sugars to Acid as Malic.
Sweet apples,	1 : .010 to .025
Mild sub-acid,	1 : .025 to .035
Sub-acid,	1 : .035 to .045
Acid,	1 : .045 to .060
Very acid,	1 : .060 to .085

It has been said that a low percentage of insoluble solids is necessary for high quality in dessert fruits. For cooking purposes this is of minor importance, and the ratio of sugars to acid is narrowed; that is, the relative amount of acid should be larger than in dessert fruits.

Apples of good shipping quality have invariably a high percentage of insoluble solids, and as this is opposed to high dessert quality, it follows that we should not expect to find the highest table quality and highest shipping quality in the same fruit. Most varieties that keep well have a relatively high proportion of their sugars in the form of sucrose. It appears that an apple in order to keep well must be well nourished, and have stored up a large amount of soluble solids, principally in the shape of sugars. Table 1 shows the averages of a number of analyses of most of the varieties that have been examined. In these averages only analyses of normal, well-grown and well-ripened fruit have been included.

TABLE 1. — *Average Analyses of Varieties (Per Cent.).*

	Number of Analyses.	Total Solids.	Insoluble Solids.	Soluble Solids.	Reducing Sugars.	Sucrose.	Total Sugars.	Acid as Malic.	Ratio, Total Sugars to Acid.
Wealthy,	3	13.84	2.11	11.73	7.40	1.71	9.11	.50	1: .055
Maiden Blush,	3	14.59	2.66	11.93	4.80	3.14	7.94	.63	1: .079
Fameuse,	5	15.09	2.64	12.45	7.72	1.38	9.10	.39	1: .043
McIntosh,	6	14.48	2.32	12.16	7.21	1.91	9.12	.38	1: .042
Jonathan,	10	15.19	2.38	12.81	8.28	1.65	9.93	.42	1: .042
Grimes,	11	17.88	2.70	15.18	8.77	4.30	13.00	.45	1: .035
King,	2	16.48	2.45	14.03	8.43	2.39	10.82	.38	1: .035
Rhode Island Greening,	4	15.82	2.89	12.93	6.10	3.27	9.37	.59	1: .063
Northern Spy,	10	14.93	2.39	11.54	8.00	2.22	10.22	.44	1: .043
Baldwin,	9	16.19	2.71	13.48	5.74	3.91	9.65	.55	1: .057
Esopus,	2	17.79	2.67	15.12	7.00	3.66	10.66	.56	1: .053
Yellow Newton,	2	16.48	2.75	13.73	7.59	3.07	10.66	.47	1: .044
Winesap,	7	17.42	2.71	14.71	10.02	2.20	12.22	.47	1: .038
Stayman Winesap,	3	15.83	2.78	13.05	8.11	3.44	11.55	.52	1: .045
Rome Beauty,	3	15.72	2.89	12.83	6.77	3.16	9.93	.41	1: .041
Smith Cider,	2	17.37	3.30	14.07	7.54	2.37	9.91	.51	1: .051
Roxbury Russet,	4	18.73	2.82	15.91	7.43	4.85	12.28	.59	1: .048
York Imperial,	7	14.69	2.69	12.00	7.96	3.04	11.00	.39	1: .035
Ben Davis,	11	15.66	3.07	12.59	6.91	2.95	9.86	.44	1: .045

We may now proceed to the discussion of each of these varieties, and will endeavor to set forth the appearance and quality of these varieties when grown to their highest perfection. The conditions under which perfection is attained, and the effect of unfavorable conditions, are discussed in detail in a later section of this paper. These descriptions are not intended to be complete descriptions of the variety, but should be read in connection with a technical description, if one is not already familiar with the general appearance of the variety.

Wealthy. — Well-grown Wealthies should be about 75 to 80 millimeters in diameter and well colored over the entire surface. The color should be a deep, rich red, distributed in the form of stripes and splashes, deepening to a blush on the sunny side. Poor color is a sign of imperfect development in this fruit. The apple should be very symmetrical in form and appearance. It is altogether a handsome fruit when well grown. The chemical analysis shows that the variety is low in total solids, a condition that we find in most summer and early fall varieties. It is low in all the constituent solids except acid. This high ratio of acid to sugar makes it a good cooking apple, but its low content of insoluble solids makes it acceptable for the table, in spite of its rather low content of sugars.

Maiden Blush. — The well-grown Maiden Blush is of about the same size as the Wealthy, of a clear waxen yellow color, with a generous bright red blush on the sunny side. It is fairly high in solids, and, for a fall apple, is especially high in sucrose. The total sugars are, however, rather low, and the insoluble solids and acid high. Its chemical analysis indicates it to be a good cooking apple and fairly good for table use for those preferring an acid fruit.

Fameuse. — Fameuse should attain a diameter of at least 70 millimeters, and a deep red, almost crimson color, over nearly its entire surface. Its chemical analysis shows its excellent table quality, although the percentage of insoluble solids is somewhat high. The relation of sugars to acid is good. It is remarkably low in sucrose and not particularly high in total sugars.

McIntosh. — The McIntosh should grow a little larger than

the Fameuse, reaching about 80 millimeters. The color should be a deep, rich crimson, a little lighter on the shady side and showing sometimes rather obscure splashes and stripes. This variety is one of the most highly esteemed as a dessert fruit. The low content of insoluble solids is in accordance with this estimate, though it does not express fully the excellent texture of this variety. Neither does the analysis give indication of its agreeable aroma and flavor. The content of sugars is good for a variety of its season and the ratio of acid is excellent. The analysis in many ways closely resembles that of the Fameuse, thus indicating the relationship considered to exist between the two varieties.

Jonathan.—This is a favorite table apple of high quality. It should attain a diameter of 70 to 75 millimeters and be of a deep rich straw yellow, almost completely covered with a deep, rich crimson blush. It is a very handsome apple when well grown. Its tender flesh is indicated by its low content of insoluble solids. It is only fairly high in sugars even for a variety of its season, and on this account lacks the richness of flavor of the Grimes and Roxbury Russet. Its ratio of sugars to acid places it among the sub-acid varieties.

Grimes.—Grimes when well grown should reach a size of 75 to 80 millimeters or more, and should be, when ripe, a clear waxen yellow, and may be covered with a slight russetting over the entire surface. When grown in dry climates this russetting may appear in only a slight degree or not at all, a condition which perhaps adds to the good appearance of the fruit. The Grimes is remarkable for its high content of total solids, largely in the form of sugars, and of these a large proportion is in the form of sucrose. The last fact, together with its rather low content of acid, accounts for the almost sweet taste of this variety.

King.—The King when well grown should be not less than 80 to 85 millimeters in diameter, and may be quite variable in form, but should be colored over its entire surface with a deep, rich red, somewhat splashed and mottled. Inasmuch as only two samples of this variety were analyzed, less dependence can be put on the figures given than could be if a larger number had

been examined. Its high quality is shown in its analysis, but it is due to no one constituent. The King is good in every respect. It is a more acid apple than the Grimes, although the ratio of sugars to acid is the same. This is due to the fact that a smaller proportion of the sugars is in the form of sucrose.

Rhode Island Greening. — The Rhode Island Greening should reach a size of about 85 millimeters and possess a clear, greenish-yellow skin. It may show a faint red blush on the sunny side, although this character may not appear in fruit that is otherwise well developed. It is generally considered a variety of excellent cooking quality, and this is shown in its high ratio of acid to sugars and in its relatively high sucrose content, while its high content of insoluble solids does not detract from its value for this purpose.

Northern Spy. — The Northern Spy is reputed to be one of the highest quality of winter varieties. It should reach a size of 80 to 85 millimeters, and be well covered with bright red stripes and splashes. Spies of poor color are frequently, though not always, of inferior quality, depending on the nature and cause of the inferiority. The low content of insoluble solids of the Spy is in accordance with its well-known tenderness of flesh and the readiness with which it bruises.

Baldwin. — The Baldwin should reach a size of 75 to 80 millimeters, and be of even deeper color and more evenly distributed. It is a better shipping apple than the Spy, but hardly as good for the table. This condition of affairs is indicated in its higher percentage of insoluble solids. It is also higher in sucrose and in the ratio of acids to sugar.

Esopus. — This variety should reach a diameter of 75 millimeters at least, and the skin should be a deep, rich straw yellow, almost completely covered with deep, rather dull red splashes and stripes. This, like the Jonathan, often appears with a poor color, indicative of imperfect development. The Esopus stands among the best as an all-round high quality variety, and its chemical analysis is in accord with this. It is about medium in its content of insoluble solids, indicating that it is sufficiently firm of flesh to ship and cook well, but not enough to seriously

injure its table quality. It is about medium in sugars and the relative amount of sucrose is fairly high. Its ratio of sugars to acid places it among the more acid table fruits and less acid cooking varieties.

Yellow Newtown. — The Yellow Newtown should be from 80 to 85 millimeters in diameter, of a clear, greenish-yellow color, sometimes slightly blushed on the sunny side, and may often show over a considerable portion of the surface a grayish scarf skin characteristic of the variety. Its analysis indicates it to be of somewhat firmer flesh than the Esopus and somewhat less acid; otherwise, it is very similar in its constitution.

Winesap. — The Winesap should be about 75 millimeters in diameter, and should be deeply colored, although the color is hardly as dark as that of Jonathan. It should, however, when well grown, show little or no signs of the ground color of the fruit. Its analysis places it in the highest class. It is rather high in insoluble solids, but very high in sugars, being exceeded only by the Roxbury and Grimes. However, a smaller portion of the sugar is in the form of sucrose than in either of the other two sorts.

Stayman Winesap. — This variety is quite similar to the Winesap. It should reach a little larger size and is not quite as red in color. The ratio of acid to sugars is somewhat higher, but this excess of acid is obscured by the higher amount of sucrose, so the acidity of the apple is about the same to the taste.

Rome Beauty. — As only three samples of this variety have been examined we do not feel like venturing on any very positive statements in regard to it. It would seem to reach a size of 80 millimeters and a color somewhat less marked than other red varieties. It shows a relatively high proportion of sucrose, but is only fair in the amount of total sugars. It is rather high in insoluble solids to be a good table fruit, and altogether the analysis is not indicative of very high quality.

Smith Cider. — The same remarks concerning the study of the Rome Beauty will apply to this variety. Very few samples have been examined, and how typical the analysis given is,

the writer does not feel confident. It is remarkably high in insoluble solids, but whether this characteristic is constant or not will require further study to determine.

Roxbury Russet. — The Roxbury Russet should reach a size of 75 to 80 millimeters. The amount of russetting is dependent on climate. A moist atmosphere during the early stages of growth seems to contribute to the increase of russetting. Its analysis shows a high content of sugar, a large proportion of which is in the form of sucrose. It is also high in acid, but in view of the amount and form of the sugars it is not particularly acid to the taste. It is high in insoluble solids, indicating firmness of flesh and good shipping qualities. Altogether, it is one of the high quality varieties, as indicated by its chemical composition.

York Imperial. — The York Imperial should reach a size of about 80 millimeters, and be of a clear waxen yellow, partially overlaid with a pinkish red. Sometimes this over color deepens to a moderately dark red, but this is not necessary to the attainment of high color and pleasing appearance. Its analysis indicates its sub-acid flavor, and it shows as low a ratio of acids to sugars as any of the varieties here reported.

Ben Davis. — The Ben Davis should attain a diameter of 75 millimeters, and fairly deep red color over almost its entire surface. Partial coloration in this variety is a sure sign of imperfect development. It enjoys the reputation of being one of the best varieties to ship and keep, and one of the poorest for both kitchen and table uses. This opinion is supported by its chemical analysis. It is especially high in insoluble solids and low in everything else, although the proportion of sugar in the form of sucrose is fairly high. The total sugars, however, are low for a winter variety. Its serious deficiency as a table fruit is its high insoluble solids content, and as a kitchen fruit its low ratio of acids to sugar.

V. THE INDIVIDUALITY OF THE TREE.

The question of the individuality of the tree has already been mentioned (see page 179). The careful measurements that have been made of the apples from several Ben Davis and Baldwin

trees for the past three years afford some interesting data on this point. The trees are on nearly level land at the top of a slope. The soil is a uniform gravelly, clay loam, and the trees are of the same age, and vary only a little in size. In the years 1908-10, every apple borne to maturity by these trees has been measured, as described in the last report of this station,¹ and the results for the individual trees are presented in Table 2.

¹ Report Massachusetts Experiment Station, 1910, p. 198.

TABLE 2. — *Apples from Different Trees.*

				Size.			Form.		
				Mean.	Standard Deviation.	Coefficient of Variability.	Mean.	Standard Deviation.	Coefficient of Variability.
<i>Davis.</i>									
Tree 2:—									
1908, .	.	.	.	71.02 ± .14	6.16 ± .10	8.67 ± .14	1.1422 ± .0014	.0576 ± .0009	3.04 ± .08
1909, .	.	.	.	70.89 ± .22	5.40 ± .16	7.62 ± .18	1.1248 ± .0024	.0553 ± .0017	4.91 ± .15
1910, .	.	.	.	73.15 ± .19	5.69 ± .13	7.78 ± .15	1.1159 ± .0016	.0516 ± .0012	4.62 ± .12
Tree 3:—									
1908, .	.	.	.	68.80 ± .15	5.31 ± .11	7.79 ± .16	1.1399 ± .0016	.0543 ± .0011	4.73 ± .09
1909, .	.	.	.	68.48 ± .19	5.24 ± .13	7.65 ± .22	1.1297 ± .0020	.0553 ± .0014	4.89 ± .19
1910, .	.	.	.	72.27 ± .19	6.01 ± .13	8.32 ± .22	1.1322 ± .0015	.0488 ± .0011	4.31 ± .11
Tree 5:—									
1908, .	.	.	.	68.35 ± .13	5.55 ± .08	8.12 ± .13	1.1666 ± .0019	.0626 ± .0013	3.76 ± .08
1909, .	.	.	.	68.22 ± .27	4.96 ± .18	7.26 ± .33	1.1295 ± .0028	.0519 ± .0019	4.59 ± .19
1910, .	.	.	.	75.53 ± .21	5.88 ± .15	8.00 ± .22	1.1151 ± .0018	.0512 ± .0013	4.59 ± .12
Tree 7:—									
1908, .	.	.	.	72.80 ± .18	6.45 ± .13	8.86 ± .17	1.1716 ± .0019	.0578 ± .0013	3.37 ± .07
1909, .	.	.	.	70.37 ± .17	5.12 ± .12	7.28 ± .19	1.1486 ± .0017	.0611 ± .0012	4.45 ± .11
1910, .	.	.	.	75.12 ± .19	6.85 ± .14	9.12 ± .21	1.1333 ± .0014	.0516 ± .0010	4.55 ± .09
Tree 8:—									
1908, .	.	.	.	70.45 ± .13	4.93 ± .09	7.00 ± .13	1.1310 ± .0013	.0494 ± .0010	4.37 ± .09
1910, .	.	.	.	72.57 ± .09	6.16 ± .06	8.52 ± .10	1.1211 ± .0007	.0481 ± .0005	4.29 ± .05
Tree 2:—									
1908, .	.	.	.	78.62 ± .21	5.59 ± .15	7.11 ± .23	1.1615 ± .0022	.0579 ± .0015	4.98 ± .13
1910, .	.	.	.	78.84 ± .23	5.86 ± .16	7.43 ± .27	1.1745 ± .0021	.0536 ± .0015	4.56 ± .15
Tree 4:—									
1909, .	.	.	.	74.39 ± .14	5.01 ± .10	6.73 ± .15	1.1848 ± .0014	.0523 ± .0010	4.41 ± .10
1910, .	.	.	.	76.90 ± .27	5.57 ± .19	7.24 ± .30	1.1834 ± .0027	.0553 ± .0019	4.67 ± .17
Tree 5:—									
1909, .	.	.	.	77.66 ± .21	5.66 ± .15	7.29 ± .22	1.1790 ± .0024	.0644 ± .0017	5.46 ± .16
1910, .	.	.	.	77.71 ± .15	5.20 ± .11	6.69 ± .15	1.1888 ± .0018	.0622 ± .0013	5.23 ± .12

Baldwin.

A study of this table shows some positive signs of individuality in the trees in the characters of size, form and productiveness. Size is of course considerably affected by the number of apples borne, though not as much as usual in this case, as the trees have not matured a very heavy crop during the period of observation. The marked seasonal fluctuation in size will be considered later. We can say that Ben Davis trees 7 and 2 show a tendency to bear large apples and trees 3 and 5 a tendency to bear smaller fruit, though in 1910 tree 5 bore the largest fruit of any, but at the same time the crop was lightest of all. Among the three Baldwins, the rank has been the same each year, in spite of the fluctuations in productiveness. In variability there are no constant differences. In the Ben Davis there seems to be a relation between variability and number of apples produced, the greater the number of apples the greater the standard deviation and coefficient of variability, — a relation that is to be expected.

In form, the situation is much the same. Ben Davis tree 7, which produced the largest apples, has invariably borne the flattest ones, usually by a considerable margin. Tree 2 shows a fairly constant character of producing more elongated apples than its fellows. In the Baldwins, also, there are signs of slight differences between the trees.

The variation in number of apples borne by the different trees is great. Ben Davis tree 8 has averaged about three times as many apples as tree 5, and they have been larger. A part of this difference is due to the fact that tree 8 is somewhat larger than tree 5, but the difference in size is not enough to account for all the difference in productiveness.

Productiveness is one of the most important qualities of a variety or individual tree. If the tree does not produce at least a fair crop of fruit, all other valuable qualities it may possess lose their attractiveness to the commercial grower, while great productiveness covers a multitude of deficiencies. Other investigations, and common observations as well, have shown very marked differences in the bearing ability of different trees.¹ In our opinion, these differences, as well as any others which may occur, are generally due to one or more of four influences:

¹ See Macoun, Report Central Experiment Farm for 1903, p. 102.

(1) differences in soil, (2) differences in aspect or exposure, (3) some inherent quality of the tree, (4) the influence of stock.¹

That the first two of these cause difference no one will dispute, but there are many variations which can hardly be explained by differences in soil or site. It has been assumed by many that variations in productiveness arise from within the tree, and are transmissible. We know of no direct evidence to support this view. Inheritable variation in color and form has appeared in certain varieties. The Collamer, Banks and possibly Gano apples are instances of the former, and a probable case of the latter has been reported by the writer.² Whether the slight differences in form and size reported here are transmissible by bud is by no means certain. We are of the opinion that they are not, for it seems possible to explain these and the other variations in productiveness, not attributed to soil and site by reference to a different cause.

Waugh has shown that in plums different stocks produce marked modification in the trees grown on them.³ Apple stocks do not differ as widely as do the plum stocks, above referred to, but the observed differences are also less marked. Every apple tree of a named variety is growing on a stock of a different, unnamed variety, *i.e.*, a seedling. These seedlings differ to a considerable degree. May not the slight differences observed between individual trees of a variety, growing under apparently similar conditions, be largely due to the influence of the seedling root? We know of no direct evidence to support this view, but to us it seems a more promising theory than that of individuality of the different buds.

If this supposition is true, it is probable that the production of the most desirable trees of a given variety would be favored by growing on a particular known root; thus the Baldwin grown on roots of Spy, Wealthy or Siberian Crab might be an especially desirable tree, while if grown on Tolman or King⁴ it might be less desirable. Different soils and localities might be

¹ There are, of course, large seasonal fluctuations in productiveness due to conditions peculiar to the different years. These are not considered in this discussion.

² See Report Massachusetts Experiment Station, 22, Part II., p. 187.

³ Report Massachusetts Experiment Station, 21, Part II., p. 174.

⁴ The varieties mentioned are random selections for illustration. There is no reason to believe that they would influence the Baldwin as indicated.

suitied by different stocks. We know of no experiments to learn what are the preferences of different varieties or soils, but it appears to be a desirable and promising line of investigation.

VI. THE MODIFYING EFFECT OF CLIMATE ON THE DEVELOPMENT OF THE APPLE.

ON FORM.

In the last report of this station ¹ the question of the variation in form of the Ben Davis was dealt with to some extent, but without arriving at any very definite conclusion as to the cause, further than that it was climatic and closely related to the nearness of large bodies of water. Since this report was written, two years' further work have been completed, which serve to emphasize the conclusions mentioned above, and to show, further, that there are large seasonal fluctuations in the index of form. The following figures from a few selected stations will illustrate this:—

TABLE 3. — *Seasonal Variation in Form.*

	Number of Apples.	Mean Index of Form.	Standard Deviation.	Coefficient of Variability.
Charlottetown, P. E. I.: —				
1907,	74	1.0511±.0049	.0619±.0034	5.88±.31
1908,	122	1.1250±.0052	.0858±.0037	7.63±.33
1910,	135	1.0557±.0043	.0744±.0031	7.05±.29
Abbotsford, Quebec: —				
1907,	151	1.1788±.0039	.0735±.0028	6.23±.24
1908,	129	1.1739±.0041	.0683±.0029	5.82±.23
1909,	184	1.1986±.0031	.0628±.0022	5.24±.21
1910,	115	1.1356±.0029	.0455±.0021	4.01±.18
Isle la Motte, Vt.: —				
1907,	203	1.1547±.0024	.0735±.0024	6.28±.27
1908,	170	1.1406±.0027	.0526±.0020	3.74±.15
1909,	148	1.1475±.0033	.0590±.0023	5.14±.24
Amherst, Mass.: —				
1907,	284	1.1656±.0023	.0581±.0017	4.98±.14
1908,	2,321	1.1515±.0008	.0589±.0006	5.29±.05
1909,	1,866	1.1338±.0009	.0527±.0006	4.65±.06
1910,	2,914	1.1238±.0007	.0504±.0004	4.48±.04
Storrs, Conn.: —				
1907,	147	1.1557±.0030	.0534±.0021	4.62±.18
1908,	131	1.1423±.0041	.0689±.0029	6.03±.21
1909,	146	1.1330±.0035	.0622±.0025	5.49±.24
Marblehead, Mass.: —				
1908,	192	1.1021±.0029	.0598±.0021	5.42±.18
1910,	176	1.0982±.0033	.0651±.0023	5.93±.22
Sandwich, Mass.: —				
1908,	162	1.1281±.0021	.0407±.0015	3.67±.14
1909,	143	1.1167±.0036	.0654±.0025	5.86±.24

¹ Report Massachusetts Experiment Station, 22, p. 194 (1909). The reader is referred to this paper for the methods used in measuring and studying this variation in form.

This has led to a study of the differences in the climatic conditions in the different years. The apple during its early stages of growth, following blossoming, is relatively more elongated than is the mature fruit. During the later periods of growth it enlarges in cross diameter relatively more. A study of the temperature during the latter part of the summer failed to show any differences corresponding to the variations in form. An examination of the daily mean temperatures for a period at and following the blossoming period gave more positive re-

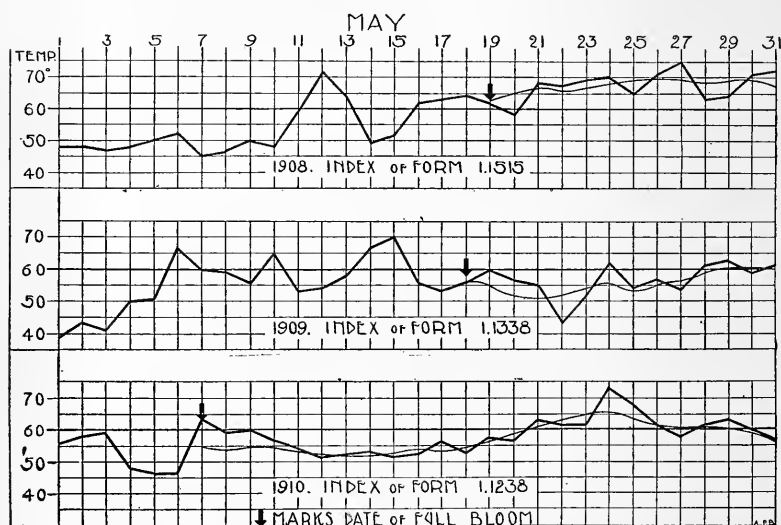


FIG. 1.

sults. At Amherst the apples measured in the last four years have been successively more and more elongated. The temperatures during the blossoming season for the last three years are shown in Fig. 1. The date of full bloom and index of form are also shown. We do not know the date of full bloom in 1907. An examination of this chart shows that the temperature for a period of two or three weeks following blossoming has been lower each year, in agreement with the greater elongation of the fruit.

We have data for a number of other stations, and all show a similar correspondence of temperature and form. Fig. 2 shows

conditions in the Lake Champlain valley, the apples being from Isle la Motte, Vt., and temperature data from Burlington. We

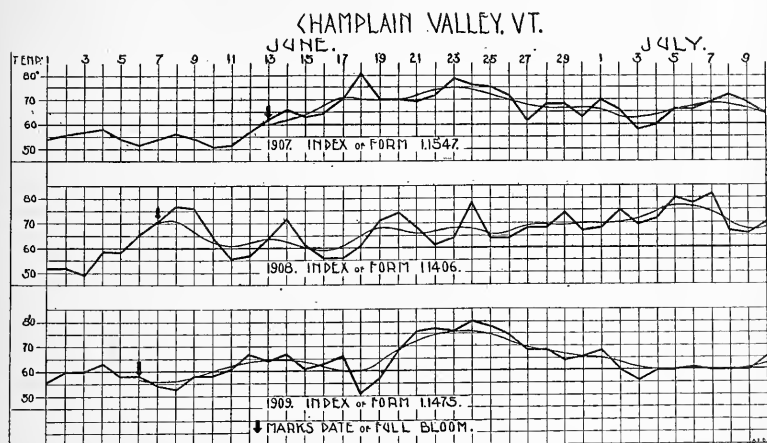


FIG. 2.

do not know the date of bloom in 1908, but it was probably not far from June 8. In Fig. 3 the temperature data are from

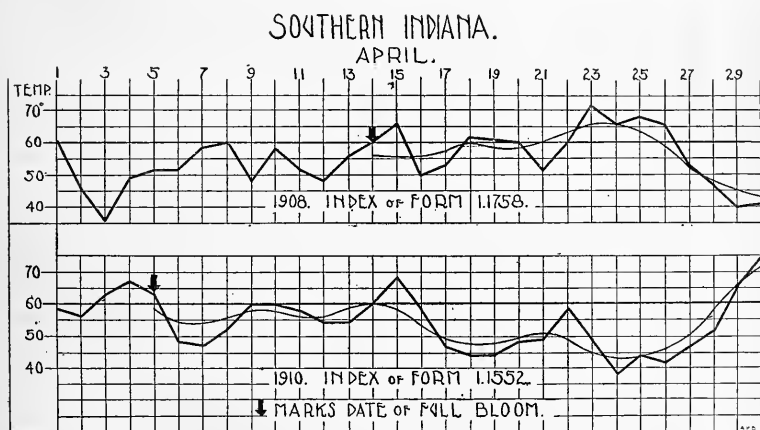


FIG. 3.

Salem, Ind., and the apples from Mitchell; in Fig. 4 both apples and temperature data are from Bentonville, Ark.

An examination of these charts shows a reasonably close agreement with that for Amherst. A period of cool weather,

proposed. If this is the correct solution we ought to expect the upper south portions of the tree, owing largely to its exposure to the warmth of the sun, to give the flattest apples, and the lower north to give the most elongated ones, with the other two portions intermediate. The calculations for the three years 1908-10 are shown in Table 4.

TABLE 4. — *Variation in Form in Different Parts of the Tree.*

	Number of Apples.	Mean Index of Form.	Standard Deviation.	Coefficient of Variability.
<i>Ben Davis.</i>				
Upper south: —				
1908,	518	1.1643±.0017	.0593±.0012	3.61±.07
1909,	552	1.1390±.0015	.0520±.0011	4.57±.10
1910,	707	1.1299±.0013	.0500±.0009	4.43±.09
Lower south: —				
1908,	714	1.1512±.0015	.0619±.0011	4.19±.07
1909,	379	1.1302±.0018	.0516±.0012	4.57±.12
1910,	893	1.1249±.0011	.0489±.0009	4.35±.08
Upper north: —				
1908,	414	1.1553±.0020	.0607±.0014	3.91±.08
1909,	305	1.1333±.0020	.0509±.0014	4.40±.14
1910,	576	1.1216±.0016	.0544±.0010	4.85±.10
Lower north: —				
1908,	676	1.1406±.0016	.0644±.0011	4.58±.07
1909,	287	1.1338±.0021	.0529±.0015	4.67±.14
1910,	869	1.1171±.0012	.0505±.0008	4.52±.08
<i>Baldwin.</i>				
Upper south: —				
1909,	467	1.1877±.0019	.0606±.0013	5.10±.13
1910,	235	1.1955±.0024	.0537±.0016	4.49±.16
Lower south: —				
1909,	290	1.1688±.0020	.0500±.0014	4.28±.14
1910,	137	1.1792±.0031	.0536±.0022	4.57±.20
Upper north: —				
1909,	327	1.1809±.0020	.0548±.0014	4.64±.13
1910,	168	1.1792±.0030	.0575±.0021	4.88±.18
Lower north: —				
1909,	177	1.1586±.0026	.0522±.0019	4.51±.18
1910,	86	1.1717±.0044	.0602±.0031	5.14±.31

The relative rank of the different parts of the trees of the Ben Davis is as follows:—

	1908.	1909.	1910.
1. Most flattened,	Upper south.	Upper south.	Upper south.
2,	Upper north.	Lower north.	Lower south.
3,	Lower south.	Upper north.	Upper north.
4. Most elongated,	Lower north.	Lower south.	Lower north.

It is seen that the upper south quarter of the tree yielded the flattest apples each year, and usually by a considerable margin, while the most elongated fruit comes from the lower portion of the tree, and, in two of the years under consideration, on the north side. On the whole the figures for the different parts of the tree support the theory already presented that the elongation is due to relatively cold weather, and gives support to the idea that the heat of the sun has much to do with the temperature of the tree itself and probably the development of the fruit.

In the Baldwins the relative rank is as follows for both years: upper south, upper north, lower south, lower north.

ON SIZE.

The size of an apple is determined by several factors. Each variety has its individuality in this respect. Culture is important, an abundance of nitrogenous fertilizers and an abundant supply of moisture being favorable to the attainment of large size. An excessively heavy crop prevents the development of full size of the individuals, but a light crop does not seem favorable to any larger fruit than a moderate one. Young trees usually bear larger fruit than mature ones, while in very old trees the fruit is commonly inferior in size. The differences due to age are probably in considerable degree at least due to the influences already mentioned.

Aside from these influences the summer temperature seems to have considerable influence. Some evidence on this point was presented in an earlier paper.¹ Table 4 (page 203) gives further data on this point.

The mean summer temperatures at Amherst were as follows: 1908, 58.8°; 1909, 56.7°; 1910, 58.9°.

The size of the apples is in a general way in accordance with these temperatures.

In 1910 the apples were much larger than in 1908, while the temperature was practically the same. This may be due to increased amounts of fertilizer which have been applied. The orchard was lined in the spring of 1909, and this may have had

¹ Report Massachusetts Experiment Station, 22, pp. 204, 211 (1909).

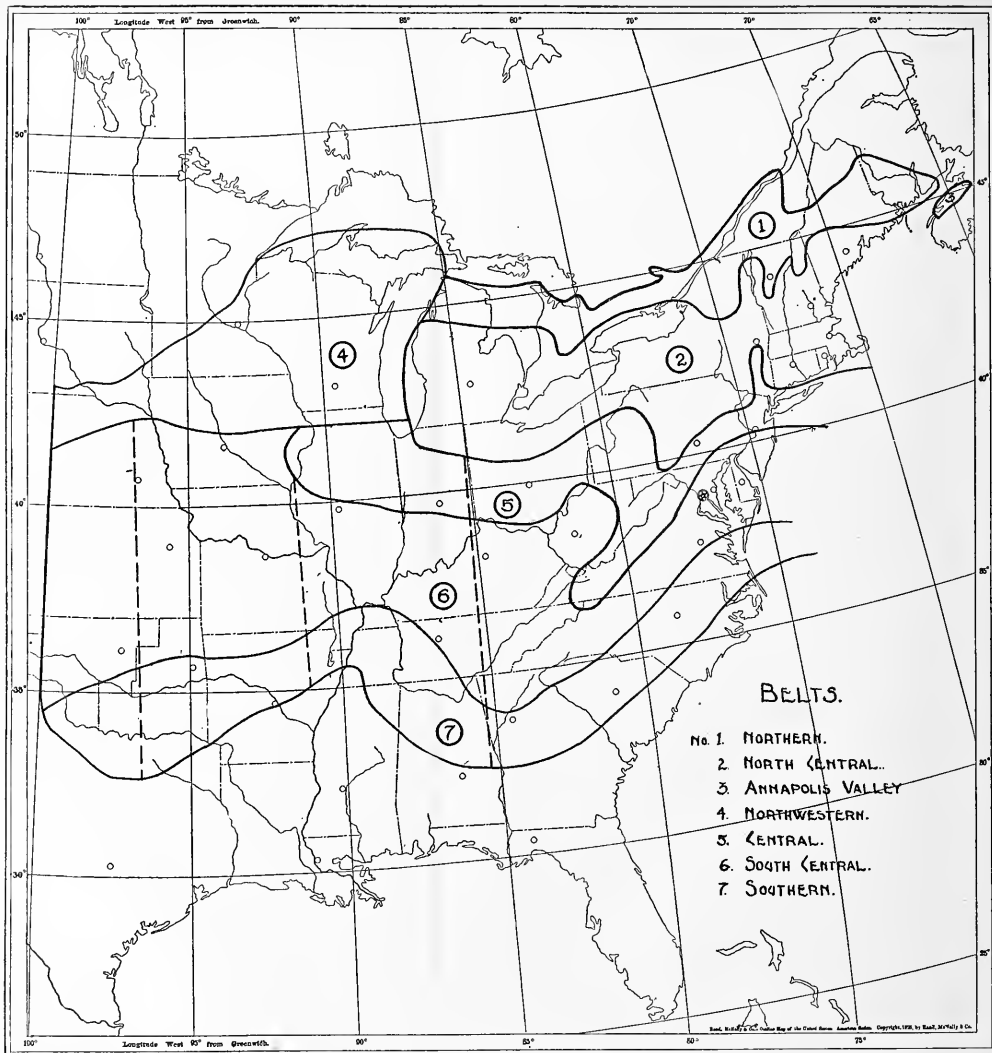


FIG. 5.—APPLE BELTS OF NORTH AMERICA.

an effect by liberating increased amounts of plant food. It does not seem possible to account for the increased size by temperature conditions.

Data from other localities similar to that previously published might be presented, but inasmuch as they show no new features, it is deemed unnecessary to do so.

ON GENERAL DEVELOPMENT.

The question of variation in form and size having been especially considered, we may now proceed to a consideration of the differences in the general development of different varieties, with more particular reference to color, keeping quality and table quality. These are the characters of paramount importance in determining the commercial value of a lot of apples. In order to discuss these questions we have found it convenient to divide the country into belts.

Apple Belts of North America.

We find in pomological writings frequent mention of different apple "belts," such as the Baldwin belt or the Ben Davis belt. This term is understood to designate a certain area over which the variety named is the leading one grown. We find many other varieties referred to a given belt, as the Northern Spy and Rhode Island Greening, which are referred to the Baldwin belt. In connection with the work herein reported, and for convenience in the discussions, the writer presents the division of North America into apple belts, shown in Fig. 5.

1. The northern belt, in which the Fameuse is the most characteristic sort.

2. The north central belt, perhaps the most recognized of any. It is characterized by the Baldwin, Northern Spy, Rhode Island Greening, Hubbardston and many others. It comprises the oldest and in some ways best understood portion of the apple region of North America.

3. The Annapolis valley, in which we find varieties similar to the second belt, but where the season is shorter and many of the varieties of the second belt do not mature well.

4. The northwestern belt, comprising the States of Minnesota and Wisconsin and adjacent territory; somewhat like the Baldwin belt to the east, but having winters too severe for many of the varieties of that belt. It is characterized by the Oldenburg, Wealthy, Hibernial, Northwestern Greening and many others.

5. The central belt, which is of less importance. There is no one variety that predominates over the whole of this territory. In eastern sections we find the Yellow Newtown, Smith Cider and Fallawater, and west of the mountains the Rome Beauty.

6. The south central belt, one of the largest and most important. There are three varieties that are quite generally spread over this belt, the Ben Davis, Winesap and York Imperial. The Grimes is quite general and important in the western part, also the Jonathan.

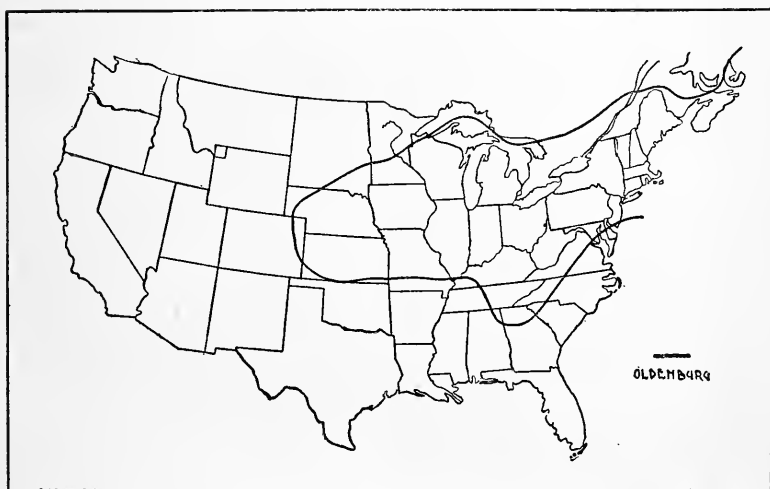
7. The southern belt, which extends to the southern limit of apple growing, and is characterized by the Yates, Terry, Shockley and Horse as leading varieties.

The figure shows these belts somewhat roughly. They depend on latitude and altitude more than anything else. Inasmuch as the altitude along the Appalachian Mountains is variable, it is impossible to show the belts with entire accuracy. Each belt will dip further south than is indicated in the higher elevations of this region. Some varieties are found generally distributed through the entire range of its belt from east to west. Others do not extend the entire length. The western portion of the territory covered has a smaller precipitation, and this may affect some varieties. More important than this, however, are the higher summer temperatures which prevail, and which cannot be successfully withstood by some varieties grown in the east. Other varieties succeed even better in this warmer summer climate than they do in the cooler and more humid east. The dotted lines in the figure show a possible division of the belts, but such division is not very definite nor of great value. No attempt is made to map the Rocky Mountain and Pacific Coast apple region, owing to the fact that the distribution of varieties there is governed largely by elevation, and would be very difficult to map, especially on so small a scale as the figure shows.

Distribution of Varieties.

A few varieties, most of them well known and of rather general distribution, have been selected for a special study in connection with this work. We may now proceed to a discussion of the distribution and some of the characteristics of these varieties.

Oldenburg. — This variety extends over almost the entire apple-growing region of North America. We find it recom-

FIG. 6.¹

mended as a commercial variety in some region of every apple belt shown in Fig. 5, with the possible exception of the southern. The two principal reasons for the wide distribution of this variety are its extreme hardiness, which enables it to withstand the severe winters of the far north, and the short season of maturity, which enables it in the south to ripen before the hot periods of July and August. In addition to this it is an early, regular and fairly abundant bearer, and not particularly subject to disease and insect injuries, and the fruit stands handling quite well.

¹ Figs. 6 to 14 are intended to show the territory over which the various varieties have been recommended as desirable commercial sorts. The places of origin of each variety, so far as known, is indicated by a cross.

Wealthy. — The Wealthy is a fall apple of rather wide distribution. It is growing in favor, especially as a filler in new orchards, and its territory of cultivation is spreading. It originated in Minnesota, and finds its highest favor in the north-western belt. It also succeeds perfectly over a greater part at least of the north central belt. It is cultivated somewhat in New Jersey, but does not find favor south of there. It will mature a little farther north than the Baldwin, and is not subject to winter-killing as is the Baldwin in severe winter temper-

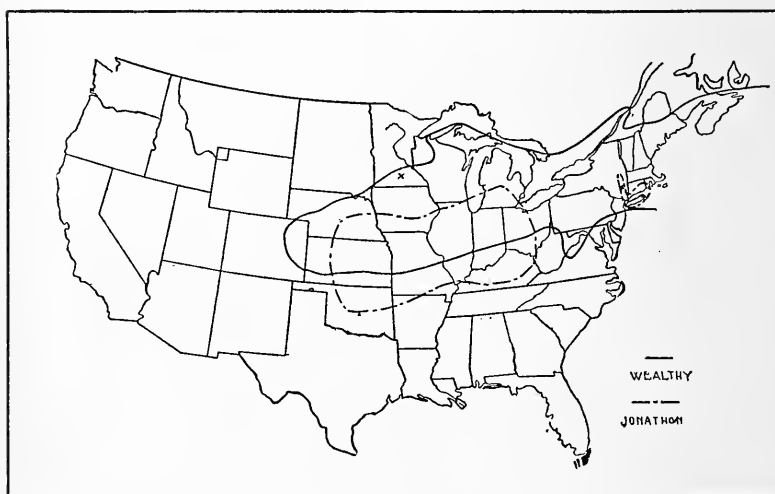


FIG. 7.

atures. It is found in greatest perfection through southern New Hampshire and Massachusetts, and along a line passing west just south of Lake Ontario and through the Province of Ontario, south central Michigan and southern Wisconsin.

Wolf River. — The Wolf River is reputed to be a seedling of the Alexander, one of the Russian varieties, and it may serve as a type of this class of apples. It is of Wisconsin origin and has attained high favor in that State. It appears to succeed best in the central and northern parts of the northwestern belt, in the northern part of the north central belt and the southern part of the northern belt. When grown too far south it does not keep well, is apt to become mealy and tasteless and is of general

inferior quality. The Russian varieties as a class are reputed to be of poor quality. They are not of the highest quality, but much of their reputation for inferiority results, in our opinion, from their being grown too far south. As a class they belong to the northern frontier of apple growing, and when grown there, many of them are equal to the better varieties of the more southern apple regions.

Maiden Blush.— This variety is a fall sort, originating in Burlington, N. J., in which State it has attained its highest

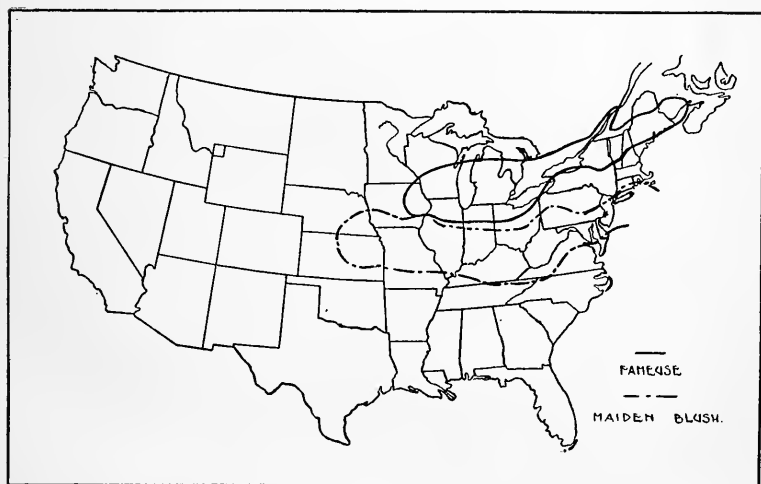


FIG. 8.

favor. It is grown with success as far north as Long Island and southern Connecticut, and west through southern Indiana and central and southern Illinois. It does not withstand the dry climate of the plains as well as some others, but reaches as far west as eastern Nebraska and Kansas. It is cultivated successfully south into the mountains of Virginia. Gould says:—

On Cecil sandy loam, at 900 to 1,000 feet elevation, it is inclined to rot severely, but on the more clayey soil of the Piedmont regions it does well. Its season of ripening varies considerably, ranging from summer to early fall. In the middle Piedmont orchards it would probably ripen in August or early September. At one point in North Carolina having an altitude of 3,500 to 4,000 feet, with rather less friable loam, some very fine specimens have been seen the middle of October.¹

¹ Bureau of Plant Industry Bulletin 135, p. 38.

It will be seen that the Maiden's Blush belongs to the central belt and the northern part of the south central belt.

Fameuse. — The Fameuse is one of the most northern of commercial apples. It is grown in most parts of the northern belt, also in northern Indiana and Illinois and in southern Michigan, though in these regions the variety does not attain the quality of the St. Lawrence and Champlain valleys. It becomes a fall apple, and is of poor color and inferior flavor. Specimens received from Prince Edward Island were dull red and green, and small in size, while those from southern Quebec were very good specimens of the variety.

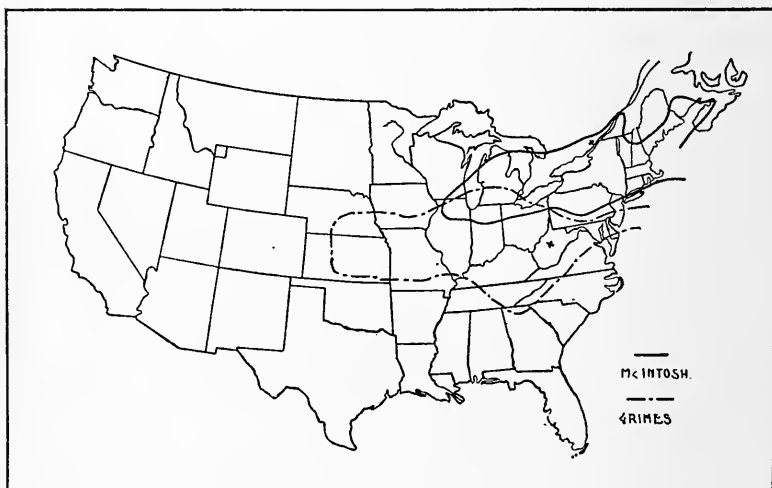


FIG. 9.

McIntosh. — The McIntosh is similar to the Fameuse and succeeds in similar territory. It does well further south, however, being at its best in south central New England and western New York. While it has been known a long time, it has not attained great favor as a commercial variety until recently, probably on account of its susceptibility to the apple scab, which has heretofore been difficult to control in a satisfactory manner. It is now gaining rapidly in popularity, and the territory of its culture is spreading. It is not grown to any extent west of Michigan, excepting in the far northwest. Throughout the Baldwin belt it is a fall apple, and south of this it becomes a

late summer or early fall variety, and is inferior in flavor and color to those grown farther north. Beach says:—

It is adapted to a wider range of localities than is the Fameuse. . . . In western New York it cannot be expected to keep much later than October in ordinary storage without considerable loss, but in cold storage it may be held until December or January. When grown in more northern or elevated regions it is often held in good condition until mid-winter or later.¹

Jonathan. — This variety had its origin in the Hudson valley, where it is now grown to a considerable extent, as well as in Long Island and southern Connecticut. It is a favorite in the south central belt west of the mountains and in favored portions of southwestern Michigan. It is at its best in central Illinois, northern Missouri and eastern Kansas and Nebraska. In Virginia and North Carolina it seems to succeed best at elevations of 1,200 to 1,500 feet or more. It has received considerable favor in the intermountain and pacific northwest apple regions, where conditions are similar to those in the regions already mentioned. It requires good care and a fairly rich soil in order to develop to its best. It should receive more attention from growers in regions where it succeeds well. It loses its sucrose in storage more readily than most varieties, after which, while still of good desert quality, it lacks the richness possessed by apples high in sucrose. It is necessary to harvest this variety at the proper time of maturity. If allowed to hang too long on the tree, especially if the weather is warm, it develops the defects of overripe apples, and will not keep well.

Grimes. — Grimes is an old Virginia apple which has spread very generally over the south central belt. It is well known over nearly all of this territory, especially in the western portion of it. Its culture extends west to central Nebraska and eastern Kansas. In the northern portion of this belt it is a late fall and early winter apple; in the southern portion it is more strictly a fall variety. It is grown to some degree north of the territory indicated, being found frequently in southern Michigan. In its more northern locations it is smaller than in

¹ Apples of New York, Vol. 1, p. 133.

the south and more acid, the latter being a quality that is appreciated by some, inasmuch as in the south the variety has a mild subacid flavor. Gould says:—

An orchard twelve to fifteen years old in Bedford County, Va., on Porters clay, at 1,500 feet elevation, with southeast exposure, produces fruit of unusual excellence, notable for its good size, fine yellow color, crispness of texture, and rich, spicy flavor. This orchard has had hardly fair care. The fruit of this variety from it reaches edible maturity early in October, but possesses good keeping qualities for the variety. On the same farm, at a point having somewhat lower elevation and a looser type of soil, it matures considerably earlier, and is not of such excellent flavor as from the location above mentioned. Produced at elevations of 2,000 feet in the upper sections of the Blue Ridge region, it may be kept under fairly favorable conditions until early winter. . . . At points south of Virginia, at the elevations of the Piedmont region, it is inclined to drop prematurely, but when grown at points having not less than 1,500 feet altitude it is highly prized in its season. One grower in the southwestern part of North Carolina has this variety at 2,500 to 2,800 feet elevation, and also at an altitude 400 to 600 feet higher. It is his experience that the fruit grown at the latter elevation will keep two months longer than that from the lower level. The fruit is also finer in appearance and more satisfactory in every way at the greater elevation. For best keeping qualities it should not be allowed to become too mature before picking.¹

Favorable reports on it have been received from certain localities in New York, but in general as grown in this State it does not develop in size, color or quality as well as it does in more southern latitudes, and there is a high percentage of loss from drops and culls.²

Tompkins King.—The King is a variety found over a limited portion of the north central belt. It is a standard apple in western New York, and is grown in southern Ontario and to some extent in Michigan. It is also a favorite variety in Annapolis valley in Nova Scotia, where it succeeds to a high degree. The tree is weak, and requires high cultivation and good care. It is scarcely known west of Lake Michigan, and is met with scatteringly as far as Virginia, where it is found in the higher levels of the Blue Ridge. The tree is

¹ Bureau of Plant Industry, Bulletin 135, p. 36.

² Beach, Apples of New York, Vol. 1, p. 154.

evidently not able to withstand the hot dry summers of the middle west.

Esopus. — This is an old variety, but one that has never been very largely cultivated. This may be partially accounted for by the fact that the tree is not particularly vigorous nor especially productive, and is somewhat susceptible to diseases. The apple is of superior quality, being much better than the Baldwin, which it considerably resembles. It has been grown somewhat in the Champlain and Mohawk valleys. It is an apple of limited cultivation for the Baldwin belt. Gould says, regarding its behavior in Virginia and North Carolina: —

At lower levels it usually drops prematurely, and even on Porters black loam at 2,000 feet elevation it often rots and drops seriously. At 3,000 to 3,500 feet altitude in North Carolina, on a rather loose loamy soil with porous subsoil containing more or less red clay, it develops more satisfactorily, keeps well into the winter, and does not manifest in any marked degree the defects observed at the lower levels.¹

It has recently attained high favor with the growers in certain portions of the Pacific northwest. In our opinion this variety is deserving of wider cultivation inasmuch as it is an excellent variety for all purposes. In fact, so far as the fruit goes we believe that none of the better known varieties of commercial apples answers so well the requirements of a general purpose market apple. When well grown it is of good size and attractive appearance, and is adapted for both dessert use and cooking. It is also a reasonably good shipping apple. It requires the better care and higher cultivation which orchards are destined to receive in the near future.

Rhode Island Greening. — The distribution of the Rhode Island Greening is very similar to that of the Baldwin, but is perhaps adapted to somewhat wider range of conditions; being a green apple it does not call for conditions adapted to the production of good color necessary for the Baldwin. It attains better size and appearance than the Baldwin when grown towards the northern limit of its culture. It is possibly somewhat hardier in tree. It is grown all through the north central

¹ Bureau of Plant Industry, Bulletin 135, p. 34.

belt, and extends somewhat further south in the higher elevations. In the south it becomes a fall apple, and is apt to ripen prematurely and drop and sometimes to decay on the trees.

Northern Spy. — This is a variety of the Baldwin belt, and its distribution is very similar to that variety, although less general. It is at its best in the Champlain valley and in western New York. Some excellent specimens have been seen from southern New England, but they do not keep as well as those from farther north. It seems to be somewhat capricious as to soils and culture, and in localities of ill success it is not always possible to determine the cause of the difficulty. When grown

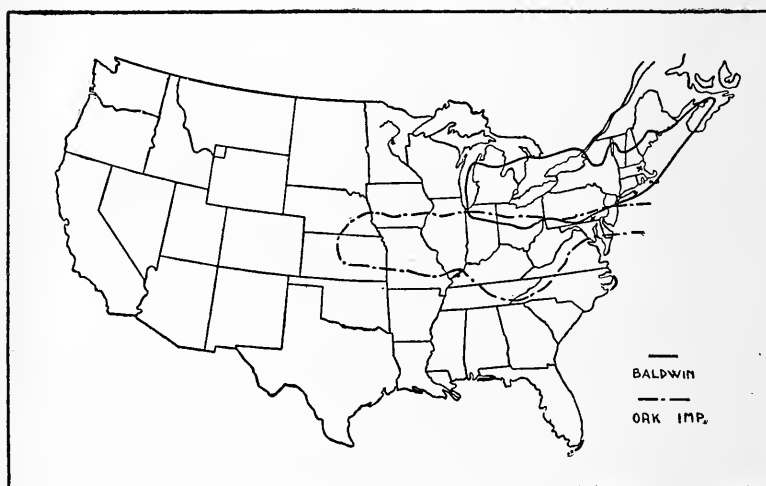


FIG. 10.

in the south it rots badly and drops, nor does it attain the high color and quality that characterize it in its more northern home.

Baldwin. — The Baldwin is the standard winter apple of the northeastern United States. It is distributed all over the north central belt, and is so nearly confined to it as to lend its name to that zone. It is also grown to a considerable extent in the Annapolis valley and very sparingly in the central belt, although it rarely attains any commercial standing in this region. It is not grown west of Lake Michigan, owing to the extremes of maximum and minimum temperatures which there

prevail. In the northwestern belt the winters are too severe and the trees winter-kill; while south of this region the summers are so warm that the variety ripens prematurely and is apt to rot and drop. These same remarks will apply to many other varieties of the Baldwin belt, most of them being too tender to withstand the winters west of Lake Michigan. The Wealthy, which is very well adapted to the Baldwin belt, is an exception to this, and grows to perfection in both regions. We have observed the Baldwin for several years in an orchard growing on the higher elevations of the Green Mountains. Here it occasionally matures pretty well. In other years it is small, dull

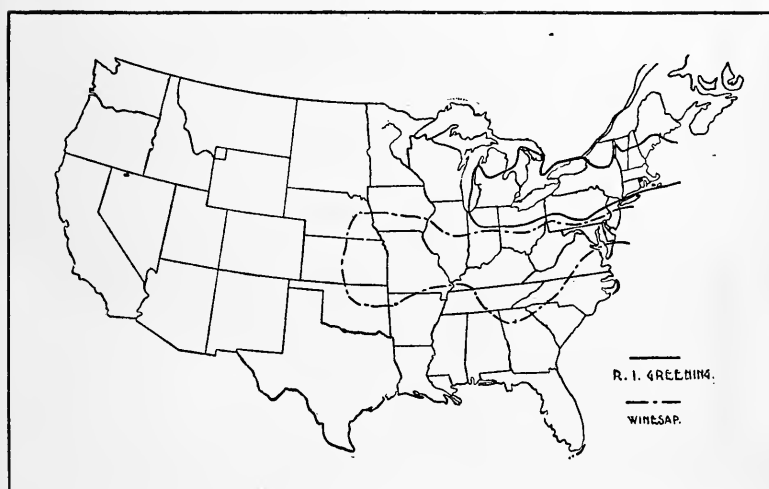


FIG. 11.

green and red in color, and of acid, astringent flavor, indicating that the variety has not had sufficient heat to mature properly. In the Champlain valley, while a standard market apple, it in most seasons fails to reach the size, color and quality that it does in western New York and south central New England. The same applies to its growth in Maine. One may observe in traveling northward through that State increasing signs of immaturity. In Massachusetts 1,000 to 1,200 feet is about the limit of certain full maturity.

Winesap. — The Winesap is a variety that has been known for a long time and has been tested over a wide area. It be-

longs to the south central belt, being grown from southern New Jersey, Virginia and North Carolina west through the Ohio valley to southern Nebraska. It reaches as far south as Georgia on the higher elevations. It reaches the highest favor in the eastern section of this belt, being of secondary importance west of the Allegheny Mountains. When grown in southern New England it is somewhat inferior in size, of doubtful color and flavor, although it keeps better than when grown in many places in its native region. It has found very little favor north of Pennsylvania and New Jersey. Specimens from Arkansas

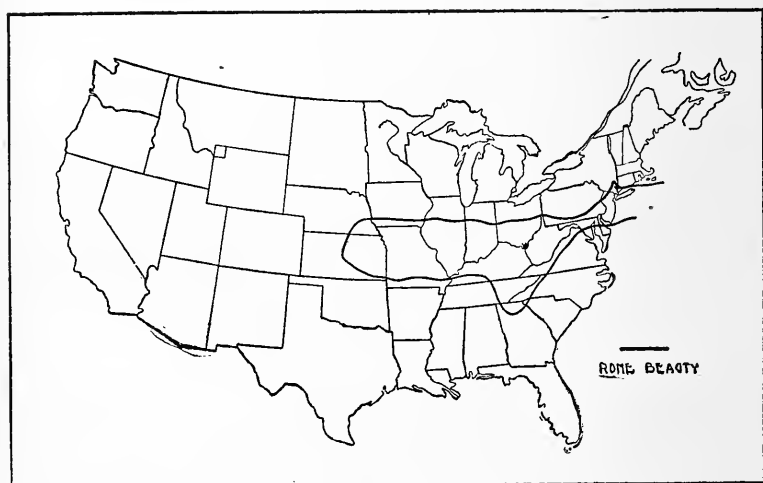


FIG. 12.

and Alabama were of medium size, though somewhat inferior in color and of only moderately good quality. Summarizing his observations regarding its behavior in Virginia and North Carolina Gould says:—

It is apparent that the conditions in the northern portion of the Piedmont region at 1,000 to 1,200 feet elevation do not produce the best results, and that in the more southern counties of Virginia which have been referred to the conditions produce very excellent fruit, but less satisfactory results are secured at points having elevations which much exceed that of the Piedmont region, while still farther south this variety can be grown at higher altitudes than is possible in the northern portion of the Piedmont. Its behavior thus indicates in an interesting way the

corresponding relationship between altitude and latitude in their influence upon the behavior of this variety.¹

Rome Beauty. — The Rome Beauty is an apple grown principally in southern Ohio, although it is found quite generally over the entire middle portion of the central belt. It is mentioned as a valuable commercial apple for Maryland, Delaware, southern Ohio, southern Indiana and southern Illinois. Specimens from Arkansas were of poor quality, but were of good size and color.

In Virginia, on Cecil sandy loam, at 900 feet, it is especially satisfactory, particularly in view of the fact that these conditions are unfavorable to most varieties. So grown, it is said to keep until the holidays. Cecil clay and Porters clay at elevations of 1,000 to 1,500 feet, in the northern Piedmont and Blue Ridge regions, usually combine conditions which are favorable to this variety. At 1,500 feet altitude on Porters clay it becomes an early winter variety of very fine appearance and good dessert quality. As a rule, it is considered especially well adapted to sandy soil. On Porters black loam, at 2,300 feet, it is considered of more than usual value. It is highly prized in western North Carolina, where it occurs at an altitude of 3,000 feet, on a deep porous mountain loam. It is, however, somewhat inclined to drop.²

York Imperial. — While the York Imperial is believed to have originated fully one hundred years ago, its period of commercial development extends over a much shorter time. It came from southeastern Pennsylvania, and there it has attained its greatest commercial value. It has spread, however, over nearly the whole of the south central belt. It is recommended as a valuable commercial variety in New Jersey, through southern Ohio to southern Iowa and Nebraska. To the south it is much valued as far as North Carolina on the higher elevations and west through Missouri and eastern Kansas. Its distribution is therefore very similar to the Ben Davis, although it has not spread into northern localities as has that variety, nor does it extend quite as far west. As to its behavior in the southern Appalachian Mountains Gould says: —

It appears to be less influenced by soil conditions than by elevation. In the Piedmont orchards having less than 1,000 to 1,200 feet elevation

¹ Bureau of Plant Industry, Bulletin 135, p. 46.

² Gould, Bureau of Plant Industry, Bulletin 135, p. 43.

serious rotting and premature dropping are apt to occur, and while frequent exceptions to this have been observed, it is sufficiently constant to suggest that extensive plantings of it in this region should be made cautiously, if at all, except in the northern portion, where it appears to be more nearly free from serious faults than almost any other commercial variety that is being grown, and is considered one of the most profitable sorts. This applies specially to locations in Rappahannock County, in close proximity to the mountains. In the Blue Ridge region above an elevation of 1,200 to 1,500 feet premature dropping is generally less severe than it is at lower points. Especially satisfactory results have usually been obtained on Porters clay at these middle elevations, where very heavy crops are expected, at least in alternate years. If heavy dropping occurs in such cases, a sufficient quantity of fruit

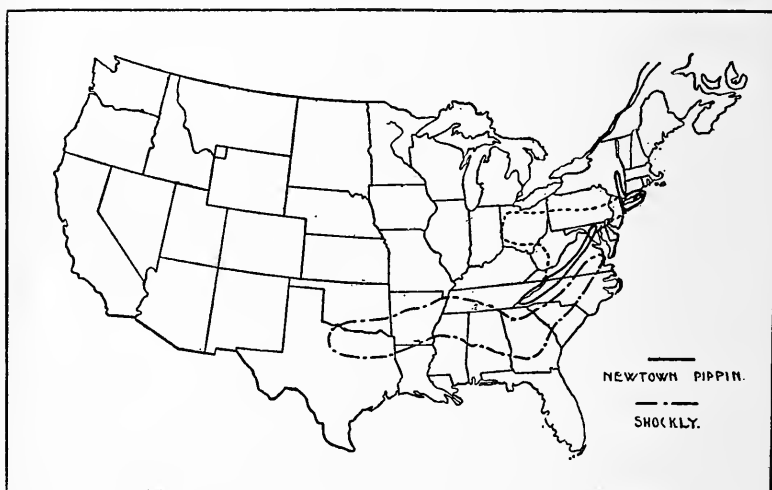


FIG. 13.

usually remains to result in a heavy crop. At the higher altitudes this is considered a valuable variety, especially in North Carolina, where it has grown at 2,500 to 3,500 feet altitude. . . . The contrast between this variety and Winesap in the manner in which they respond to the influence of elevation is of interest. The elevation at which Winesap begins to deteriorate and above which it becomes more inferior as the elevation increases appears to be about the point below which York Imperial is inclined to manifest certain faults which tend to disappear at higher altitudes.¹

Yellow Newtown. — This variety is one of restricted cultivation. The only region in the east where it can be said to have

¹ Bureau of Plant Industry, Bulletin 135, p. 49.

commercial standing is in the Hudson Valley and Long Island, and in the Upper Piedmont and Blue Ridge sections of Virginia and North Carolina. It has also attained favor in certain sections of the Pacific northwest. It is therefore an apple of the central belt. The climatic conditions, particularly the mean summer temperature, of the several regions where this variety is cultivated are even more alike than is indicated by the temperature map. The tree makes a slow growth and is rather late in coming into bearing. The variety requires better care than do many of the leading commercial sorts. The tree is evidently unable to withstand the conditions of the western plains, and apparently does not succeed west of Indiana. We are confident, however, that if given good care it will do well in many places in Pennsylvania and central Ohio, provided, also, that the soil conditions are right. Gould devotes considerable space to a discussion of the behavior of this variety in the southern Appalachians, mostly with reference to its soil preferences. He concludes that it requires a soil of high fertility and of a loose, friable texture; and a subsoil comparatively open and porous. Bearing on climatic conditions he says:—

This apple is found principally in the mountains, at various altitudes and in coves where Porters black loam abounds, often at elevations not exceeding the general level of the Piedmont. Even these lower points, where the drainage is good, are favorable places for this variety, though the higher altitudes are to be preferred.¹

In Nelson County, Va., the slopes of the mountains and hills at elevations of 1,000 to 1,500 feet are considered desirable locations. In northeastern Georgia premature dropping was observed. In Fig. 13 the solid line shows where the variety is generally recommended, and the dotted line includes additional territory where we believe it would do well in favorable locations and with good care.

Ben Davis. — This variety has been quite fully dealt with in a previous publication.² We have little to add to the statements made at that time. Many other samples of the variety have

¹ Bureau of Plant Industry, Bulletin 135, p. 48.

² Massachusetts Experiment Station Report, 1910, p. 197.

been studied and additional data as to variation in form and size have been secured, and these are set forth in an earlier portion of this paper. It cannot be grown to its full development north of southern Pennsylvania, central Ohio and Indiana, north central Illinois and central Iowa, although it is often a profitable commercial variety further north than this. It is, however, inferior in most respects to the variety grown south of that line. It is apt to be hard and astringent and poorly colored, and undersized unless grown under relatively high cultural conditions. The map given in Fig. 14 shows the

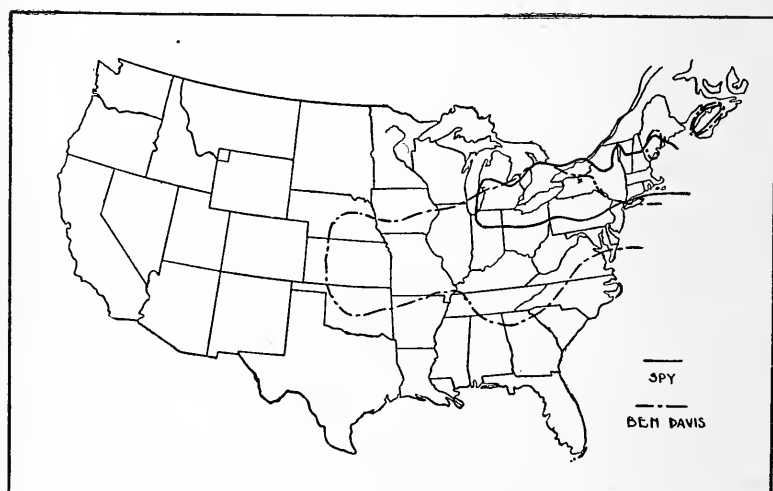


FIG. 14.

distribution of this variety. This shows it extending farther north than the map given in a previous report. It should be borne in mind that the previous map shows the area over which it is the leading commercial variety and the present map the area where it may be said to rank as a valuable commercial sort.

Shockley. — Shockley is a variety belonging almost exclusively to the southern belt. It flourishes in regions where the summer heat is greater than that favorable to most commercial varieties. It is recommended for cultivation in the hill and pine belt regions of South Carolina, and west through northern and central Alabama to northeastern Texas. Gould gives the

following concerning its behavior in the southern Appalachian Mountains: —

At 1,500 feet altitude in Albemarle County, Va., on Porters clay, this variety is not considered of special value, but at the same elevation in Georgia on a soil containing rather more sand than Porters clay does, with good culture it comes to a high degree of perfection, and when held until midwinter it generally brings very satisfactory prices in local markets. In the southwestern part of North Carolina, at 1,700 feet elevation, on a friable, porous loam, with good culture it bears annual crops of highly colored fruits, which develop to a larger size than under most conditions. In North Carolina at 3,500 to 3,800 feet, while the Shockley bears heavily and colors well, it is usually too small to be of much value, especially as other more desirable sorts succeed at these elevations. The clay and clay loam soils of the Piedmont region, with the usual elevations of those soils, may be expected, as a rule, to produce this variety in a fair degree of perfection.¹

The Relation of Temperature to Development.

The Mean Summer Temperature. — There is a close relation between the mean summer temperature and the development of the fruit. For every variety there can be determined a mean summer temperature at which it reaches its highest and most satisfactory development. Any departure from this mean results in greater or less inferiority of the fruit, the degree of inferiority depending on the amount of the departure, and the variety. For the successful growth of the tree the mean summer temperature is of little significance, but the major controlling factors are the minimum winter temperature and the mean of the hottest part of the summer. Other factors enter in, but we believe that these are the principal ones and must first be complied with if a variety is to succeed.

The Winter Minimum. — The temperature which a tree of a given variety can withstand cannot be stated with definiteness. It depends not only on the degree of cold, but also on the condition of the tree and the rapidity and amount of the fall and subsequent rise of the temperature. In the northwestern belt this is the great problem of apple culture, and much study has been given to it. The Minnesota Horticultural Society men-

¹ Bureau of Plant Industry, Bulletin 135, p. 43.

tions the following varieties as of sufficient hardness to endure the severe winters of that State:¹ —

Of the first degree of hardness, Oldenburg, Hiberna, Charlamoff, Patten, Okabena.

Of the second degree of hardness, Wealthy, Tetofski, Malinda, Peerless, Northwestern Greening.

Many other sorts thrive in the more favorable parts of this belt, but the great bulk of the varieties grown in localities of similar summer temperatures in the east perish from winter-killing. The minimum winter temperatures in this territory, according to the records of the Weather Bureau,² are around —40° F., which may be considered a degree of cold which any tree of *Pyrus malus* can rarely endure without injury (see Fig. 15). It should be borne in mind that this temperature must be taken in accordance with the methods of the Weather Bureau and with correct instruments, else the figures obtained are likely not to be comparable.

The Heat of Summer.— A glance at the figures (Figs. 6–14) giving the distribution of varieties shows that some extend the entire length of its belt, while others succeed well only through the eastern portion. There are three differences between the eastern and western portions of these belts. In the west we find (1) lower humidity, (2) less precipitation, (3) more severe heat during the summer. Probably all these have their influence in limiting the western spread of certain varieties, for their effects on the plant are similar, in that they tend to dry it out. In relative importance the greater heat is probably of the greatest significance followed by rainfall and humidity.

The Effects of Low and High Mean Summer Temperatures.— The effects on the fruit of a low summer heat, as indicated by the mean summer temperature, are as follows:—

1. *Greater Acidity.*— It is shown that the acidity of the fruit steadily decreases all through the stages of growth, ripening and decay. It naturally follows that if the fruit does not have time to mature properly it will be acid, and this is clearly shown in the table of analyses.

¹ Report, 1907, p. 34.

² United States Weather Bureau, Bulletin Q.

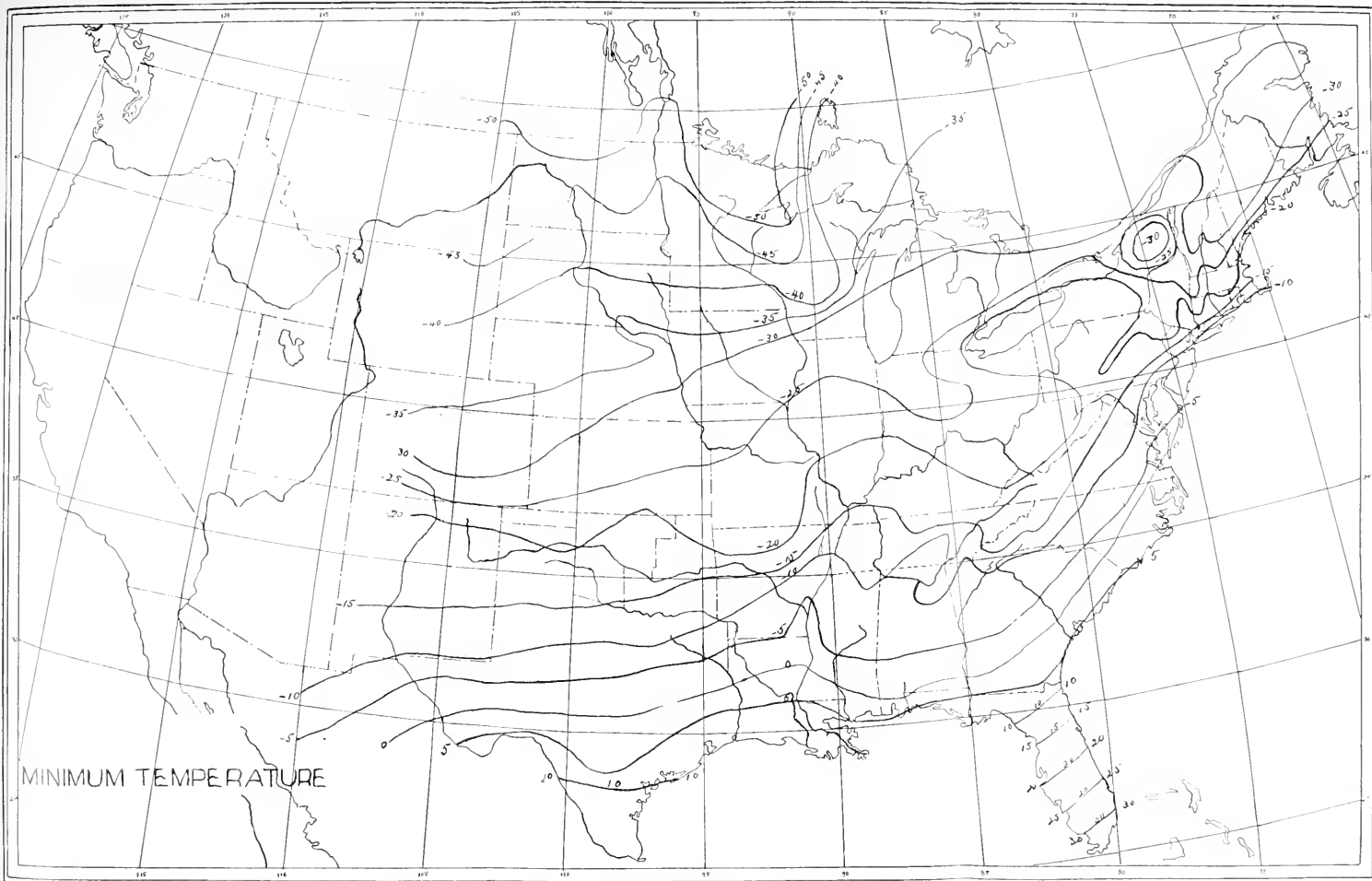


FIG. 15.—ISOTHERMS OF MINIMUM WINTER TEMPERATURE.



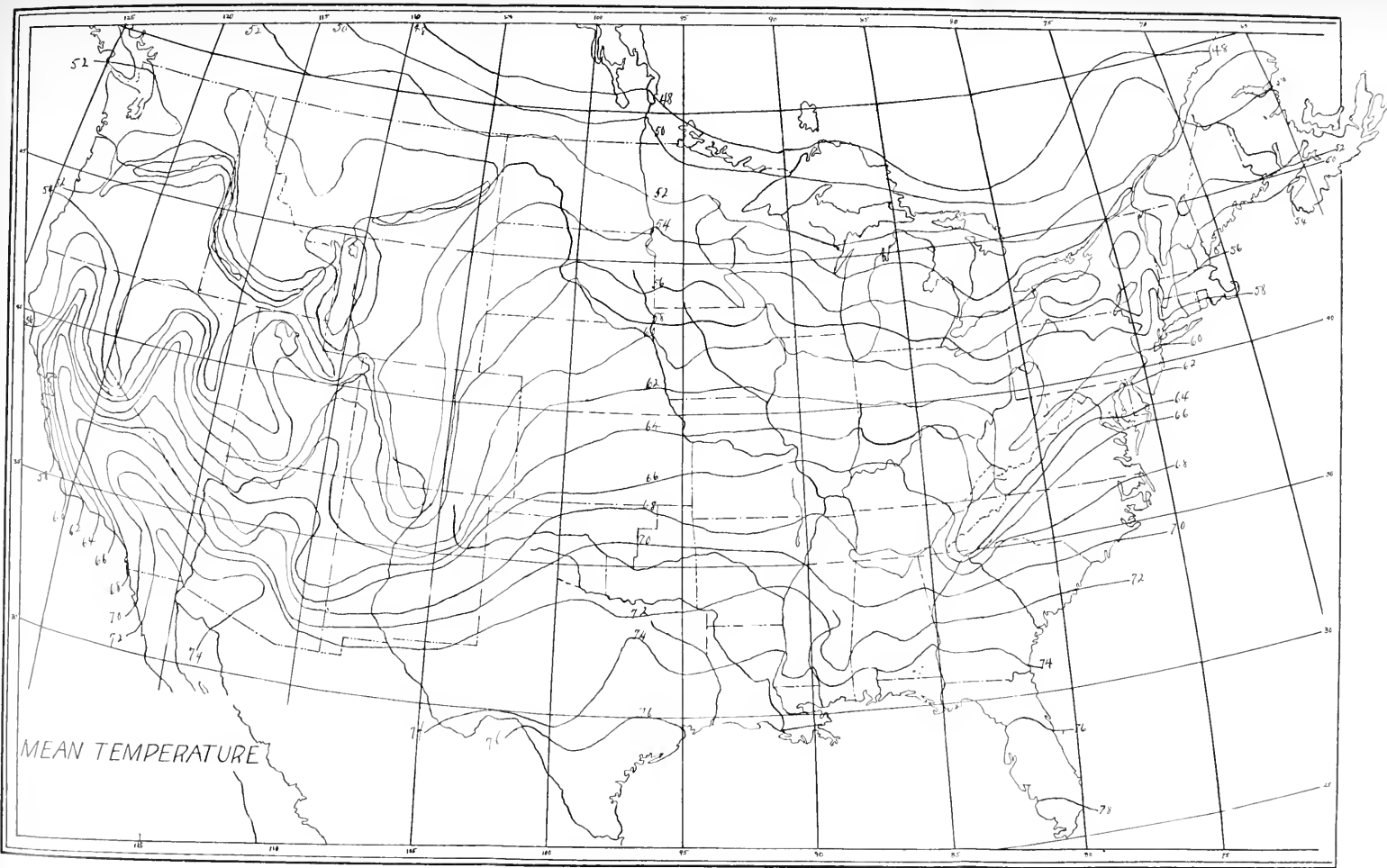


FIG. 16. — ISOTHERMS OF MEAN SUMMER TEMPERATURE. -



2. *A Higher Content of Insoluble Solids.* — The analyses show that there is a decided tendency for the insoluble solids to decrease during the stage after ripening. The figures do not show just when the content of insoluble solids is highest, but it must be at or before the time of picking. The analyses also give clear indication of the immaturity of the fruit when grown too far north. This is especially marked in the case of the Ben Davis, doubtless owing to the fact that some lots of this variety came from the far north of the region in which it matures properly, and it falls far short of full maturity. It shows an average content of 2.97 per cent. for the Ben Davis belt and 3.60 per cent. for the specimens from north of this region. Other sorts show similar differences.

3. *Greater Astringency.* — All apples in an immature state doubtless contain small amounts of tannin. No determinations of tannin have been made in connection with this work, nor have we discovered any report that shows conclusively just what changes in tannin content go on in the growing and ripening fruit. Nevertheless, it is evident to the taste that green apples have greater astringency than do ripe specimens, and we have repeatedly observed a markedly greater astringency in northern-grown apples than in the same sort grown farther south.

4. *Less Coloration.* — It is well known that plants exhibit brighter, more intense coloration when grown in high latitudes and altitudes. This is true of the coloration of red apples. In the north we find bright intense reds, which become duller towards the south, with a tendency toward a pinkish red towards the southern limit. The proportion of the fruit covered, however, behaves in a different way. We find the greatest proportion of color near the middle of a distribution, with a decrease to both the north and south. We find then, near the center of a distribution of most varieties of red apples, fruit well covered with fairly bright color, which is brighter and more intense in northern varieties than in those of the south.

5. *Decreased Size.* — When the season is short or cool it is natural that a variety should not reach the maximum size. It is somewhat difficult to determine, in lots of varying size, how much of the difference is due to climatic causes and how much

to cultural methods and conditions. However, in the case of the Ben Davis a study of the table on page 199 shows clearly not only the general influence of the different regions on size, but also that of different seasons, and almost invariably a lower summer mean is accompanied by decreased size.

6. *Scalding in Storage.* — It has been shown by Powell ¹ and Beach ² that immature apples are more likely to scald in storage than are those that have been well matured on the trees. In order to keep longest in storage an apple should have fully completed the stages of growth and ripening on the tree, and been picked and without delay placed and kept in a temperature barely above the freezing point of the fruit. In practice it is necessary to allow a margin for safety, owing to possible lack of uniformity of the temperature at different times and in different parts of the storage rooms, but the better the control of the temperature the closer may the ideal conditions be approached. It is probable that scalding may also appear on fruit that has been poorly grown, but still has reached full maturity. The chemical work here reported indicates that fruit matured on poor soil or under unfavorable cultural conditions may be in some respects similar to immature fruit. The poorly grown fruit is lower in most of the soluble solids.

When a variety is grown where the summer mean temperature is excessively high we note the following effects: —

1. *Uneven Ripening.* — Summer and fall varieties always show a tendency to ripen unevenly, making it desirable to make two or more pickings as the different specimens reach maturity. Late fall and winter sorts show less evidence of this, though a difference in the maturity of specimens in a lot of winter fruit may be detected without difficulty. Inasmuch as the result of growing a variety south of its natural range is to cause earlier maturity, and fall varieties tend to become summer varieties, it is to be expected that the uneven ripening characteristic of summer sorts should follow. This is not marked with winter varieties unless they are grown a considerable distance south of their most favorable localities.

¹ Bureau of Plant Industry, Bulletin 48.

² New York Experiment Station, Bulletin 248; Iowa Experiment Station, Bulletin 108.

2. *Premature Dropping.* — It is but natural that dropping of ripened fruit should follow uneven ripening, and this is commonly observed to be the case. We find, also, that apples may drop even at immature stages when the summer heat is too great for the liking of the variety, particularly when the heated period closely follows the period of blossoming.

3. *Rotting on the Tree.* — This is another sign of summer heat too great for the variety, which is right along the line of those already mentioned. It occurs with most varieties only when the heat is excessive. The Jonathan is especially subject to this trouble, because the margin between temperature that will give the maximum size, color and quality and one that will cause rotting seems to be narrow, and perhaps within the range of seasonal fluctuations. Therefore there is great danger that the apples will become overripe and decay before being picked.

4. *Poor Keeping Quality.* — This defect of southern-grown specimens is also along the same lines of those already dealt with. The apples mature to the end of the ripening or after-ripening stages, and being still subject to high temperature, continue rapidly on the road to decay. It is probable that in many cases this difficulty might be largely overcome by picking the apples at the proper stage and placing them at once in cold storage. I am informed by Mr. W. A. Taylor of the Department of Agriculture that Baldwins grown in West Virginia kept in a satisfactory manner when handled in this way. The chemical work here reported shows no material difference in the chemico-physiological processes of the growth and maturing of the fruit of a given variety, whether grown in the north or in the south, but only in the degree of completeness with which they are achieved.

The converse of this proposition is that northern-grown fruit, if well matured, will keep better than that variety grown farther south, and this indicates that any variety should be grown as far north as possible to fully mature it in the coolest seasons that are likely to occur. The progress of the stage of after ripening may be easily controlled if the proper facilities are at hand, but it is an advantage to have the air temperature low at this time unless it is desired to hasten instead of retard this stage.

5. *Lack of Flavor.* — The basis of flavor in apples has already been discussed. The leading element of flavor for discussion here is that of the flavoring oils. It appears that for high development of these a relatively cool atmosphere is desirable. Summer and early fall varieties do not, as a rule, possess high flavors, and any late fall or winter variety grown so far south that it ripens before the cool weather of autumn comes is likely to be inferior in the development of flavoring oils.

6. *"Mealiness."* — This is another sign of overripeness that is an indication that the variety is grown in too great summer heat. Mention has already been made of the softening of the middle lamellæ, which is the cause of this mealiness (see page 186). The result is that when eaten the cells separate from each other without breaking open and releasing the juices contained therein, and the apple is said to be "dry," whereas it probably contains a normal amount of water. Some varieties, the Jonathan, for example, do not show this characteristic in marked degree, but most varieties do if they can be kept long enough without parasitic decay, and the warmer they are the shorter the time necessary to bring about this result.

7. *Less Intense Color.* — A red variety grown to the south of its normal range is apt to show a less intense color, though it may be pretty well spread over the fruit. There is often a decided tendency toward a pinkish red, which may appear pale or faded in extreme cases.

Bright sunlight during the ripening period of the fruit has much to do with the attainment of high color, especially if at this time the nights are cool and frosty. But in order for these influences to have their full effect the apple must have been brought to the proper stage of development by a sufficient amount of heat during the period of growth. Underdeveloped apples do not take on a satisfactory color, no matter how favorable the conditions may be during the ripening period.

8. *Smaller Size.* — This effect does not manifest itself unless the variety is grown far to the south of its most favorable region. The signs of overripeness show themselves much sooner as one goes south over the distribution of a variety. Nevertheless, in some cases, at least, it is evident that a variety may fail

to reach its normal size on account of too severe summer heat. It is probable that this occurs most noticeably in the extreme south of the apple region. We have seen evidences of it in the Ben Davis and Winesap that were grown about as far south as these varieties are much cultivated.

The Optimum Mean Summer Temperature. — It is evident from the foregoing discussion that the development of the highest perfection in any given variety is closely related to most favorable mean summer temperatures. In Table 5 is given a list of varieties, with an estimate of the optimum temperature for each sort, and in some cases of their possible range and hardiness with respect to the cold of winter. The list of varieties includes all those that are given the double star, indicating highly successful varieties, in the list of the American Pomological Society, with a number of additions of varieties that, for various reasons, seemed worthy of consideration. Inasmuch as we consider keeping quality of considerable account with most sorts, the policy has been to prescribe about as low a temperature as will suffice to thoroughly mature a variety, leaving a margin of about 2° for seasonal fluctuations; that is, we believe that any variety may be matured when the summer mean is 2° lower than the one given. This applies more particularly to the fall and winter varieties. We believe, on the other hand, that any increase in the summer mean for any variety, unless it be the earliest ones, will be a disadvantage, though a very slight one, if the rise is not more than 1° or 2° . Up to a certain degree the overmaturity of the fruit in a too warm climate may be overcome if the grower will pick at the time of full maturity and put the fruit at once in cold storage. If the heat is too great, however, even with this method the fruit will be inferior in flavor and color, and, in very extreme cases, in size. We believe that a departure of more than 2° in either direction from the temperatures given will be a noticeable disadvantage with any of the winter varieties. This remark will apply less to the fall sorts and still less to the summer varieties; or, to put it in other words, the earlier the variety the greater may be its range of temperature without marked deterioration of the fruit. There are doubtless errors in the case of some varieties, concerning which we have limited infor-

mation. It is hoped that these may, in time, be corrected, as we are able to learn more concerning the behavior of these varieties under different conditions.

In Table 6 these same varieties are grouped under their optimum temperatures for convenience in reference.

In Table 5 there is also given for some varieties the range of temperature which they can stand without serious deterioration. This is, as already stated, closely connected with the season of the variety, being wide with early sorts and relatively narrow with most winter sorts. Just how much difference there is between the ranges of varieties of the same season is difficult to say. It is complicated with a variety of related questions.

In the case of a few of the varieties given in Table 5 an attempt is made to give their hardiness with respect to the winter cold. Inasmuch as the ability of the tree to withstand cold depends on a variety of factors other than the temperature, it is of no use to attempt to state this in degrees. The designation Ex. H. is used for the varieties equal in hardiness to those classified as of the first degree of hardiness; the designation V. H. for those of the second degree of hardiness (by the Minnesota Horticultural Society); and the designation H., M. and T. for various degrees of hardiness below these two classes. Many of the more southern sorts are not grown far enough north on account of a lack of summer heat to test their winter hardiness in a satisfactory manner. Therefore it is impossible to make any statements regarding them, nor would there be any practical value in such statements were they possible.

TABLE 5. — *Mean Summer Temperatures.*

	Optimum Temperature (Degrees).	Range.	Hardiness.		Optimum Temperature (Degrees).	Range.	Hardiness.
Akin,	52			Holland Winter,	57		
Alexander,	54		H.	Horse,	66		
Arctic,	53		H.	Hubbardston,	57		
Arkansas,	65			Huntsman,	62	N.	N.
Arkansas Black,	63			Hyde King,	60		
Babbitt,	57			Ingraham,	62		
Bailey Sweet,	58			Jefferis,	57		
Baldwin,	56	N.	M.	Jewett,	54		
Baxter,	53		H.	Jonathan,	59	N.	N.
Beach,	65			July,	59		
Ben Davis,	64	M.	H.	Kent Beauty,	58		
Benoni,	59			Keswick,	58		
Bethel,	53		H.	King David,	59		
Bietigheimer,	53			Kinnaird,	59		
Bismark,	53			Lady,	58		
Black Gilliflower,	55			Lady Sweet,	57		
Blenheim,	55			Lankford,	61		
Blue Pearmain,	54		H.	Lawver,	64		
Boiken,	57			Limbertwig,	66		
Bonum,	65			Longfield,	57		
Borovinka,	53			Lowell,	58		
Bough,	57			Lowland Raspberry,	58		
Buckingham,	66						
Buncombe,	66						
Cabashea,	58			Maiden Blush,	61	M.	V. H.
Cannon Pearmain,	65			Malinda,	54	N.	H.
Charlamoff,	53		Ex. H.	Mann,	55	M.	
Chenango,	57			McAfee,	60		H.
Collins,	65			McIntosh,	56	W.	H.
Cooper Market,	60			McMahon,	55		
Cox Orange,	35			Melon,	57		
Delicious,	59			Milden,	58		H.
Dominie,	60			Milwaukee,	54		H.
Dudley,	53			Minkler,	60		
Early Harvest,	56	V. W.		Missouri Pippin,	64		
Early Joe,	56			Monmouth,	57		
Early Pennock,	56			Mother,	58		
Early Strawberry,	58			Newell,	55		
English Russet,	56			Newtown Spitzenburg,	60		
Esopus,	59	N.		Northern Spy,	56	M.	H.
Ewalt,	58			Northwestern Greening,	55		V. H.
Fallawater,	60			Okabena,	52		Ex. H.
Fall Harvey,	57			Oldenburg,	52	V. W.	Ex. H.
Fall Orange,	57			Oliver,	64		
Fall Pippin,	58			Ontario,	56		H.
Fameuse,	54	M.	H.	Ortley,	61		
Fanny,	63			Paragon,	64		
Flushing Spitzenburg,	58			Patten,	55		Ex. H.
Foundling,	54		H.	Payne,	62		
Gano,	64	M.		Peck Pleasant,	58		
Gideon,	54		H.	Peerless,	56		V. H.
Golden Russet,	56			Pewaukee,	53		V. H.
Golden Sweet,	58			Plumb Cider,	57		
Gravenstein,	55	M.	M.	Pomme Gris,	55	N.	
Green Sweet,	58			Porter,	57	W.	
Grimes,	62	M.	H.	Primate,	57		
Haas,	59		H.	Pumpkin Sweet,	57		
Hagloe,	60			Ralls,	62		
Hibernal,	52	N.	Ex. H.	Rambo,	60		
Holland Pippin,	57			Red Astrachan,	54	W.	H.

TABLE 5. — *Mean Summer Temperatures* — Concluded.

	Optimum Temperature (Degrees).	Range.	Hardness.		Optimum Temperature (Degrees).	Range.	Hardness.
Red Canada,	59	M.		Tolman,	56	M.	H.
Red June,	58	M.		Tompkins King,	56	M.	M.
Rhode Island Greening,	56	M.	H.	Twenty Ounce,	58		M.
Ribston,	55	N.		Twenty Ounce Pippin,	58		
Rolfe,	56		H.				
Roman Stem,	61			Wagener,	59		
Rome Beauty,	60			Walbridge,	54		H.
Roxbury Russet,	57	W.	H.	Washington Royal,	56		
				Wealthy,	56	W.	V. H.
Salome,	55		H.	Westfield,	56		
Scott Winter,	55		V. H.	White Astrachan,	54		
Shiawasse,	55		H.	White Pearmain,	62		
Shockley,	65	N.		White Pippin,	61		
Smith Cider,	61			Williams,	57	W.	
Smokehouse,	60			Willow,	64		
Stark,	62	M.	H.	Windsor,	55		H.
Stayman Winesap,	63			Winesap,	64	M.	
St. Lawrence,	54			Winter Banana,	58		
Sutton,	56			Wolf River,	54	M.	V. H.
Swarr,	58						
Swazie,	55	N.		Yates,	67		
Switzer,	58			Yellow Belleflower,	61	W.	
				Yellow Newtown,	60	V. N.	
Terry,	67	N.		Yellow Transparent,	53	W.	V. H.
Tetofski,	53	V. W.	V. H.	York Imperial,	62	M.	
Titovka,	56		H.				

TABLE 6. — *Optimum Temperatures by Groups.*

52°.	53°.	54°.	55°.
Hibernal Okabena Oldenburg	Arctic Baxter Bethel Bietigheimer Bismark Borovinka Charlamoff Dudley Pewaukee Tetofski Yellow Transparent	Alexander Blue Pearmain Fameuse Foundling Gideon Jewett Malinda Milwaukee Red Astrachan St. Lawrence Walbridge White Astrachan Wolf River	Black Gilliflower Blenheim Cox Orange Gravenstein Mann McMahon Newell Northwestern Greening Patten Pomme Gris Ribston Salome Scott Winter Shiawasse Swazie Windsor
56°.	57°.	58°.	59°.
Baldwin Early Harvest Early Pennock English Russet Golden Russet Lowland Raspberry McIntosh Milden Northern Spy Ontario Peerless Rhode Island Greening Rolfe Sutton Titovka Tolman Tompkins King Washington Royal Wealthy Westfield	Babbitt Boiken Bough Chenango Fall Harvey Fall Orange Holland Pippin Holland Winter Hubbardston Jefferis Lady Sweet Longfield Melon Monmouth Plumb Cider Porter Primate Roxbury Russet Williams	Bailey Sweet Cabashea Early Joe Early Strawberry Ewalt Fall Pippin Flushing Spitzenburg Golden Sweet Green Sweet Kent Beauty Keswick Lady Lowell Mother Peck Pleasant Red June Swarr Switzer Twenty Ounce Twenty Ounce Pippin Winter Banana	Benoni Delicious Esopus Haas Jonathan July King David Kinnaird Red Canada Wagner
60°.	61°.	62°.	63°.
Cooper Market Dominie Fallawater Hagloe Hyde King McAffee Minkler Newtown Spitzenburg Rambo Rome Beauty Smokehouse Yellow Newtown	Lankford Maiden Blush Ortley Roman Stem Smith Cider White Pippin Yellow Bellflower	Akin Grimes Huntsman Ingram Payne Ralls Stark White Pearmain York Imperial	Arkansas Black Fanny Stayman Winesap
64°.	65°.	66°.	67°.
Ben Davis Gano Lawver Missouri Pippin Oliver Paragon Willowtwig Winesap	Arkansas Beach Bonum Cannon Pearmain Collins	Buckingham Buncombe Horse Limburtwig Shockley	Terry Yates

Chemical Determinations.

The work here reported is based in considerable degree on chemical work done in the laboratory of the college. During the past two years over 150 samples of apples have been subjected to partial analysis, the results of which, so far as they are deemed worthy of publication, are presented in Table 7. The names and locations of the growers are as follows:—

NAME.	Post-office Address.	NAME.	Post-office Address.
F. Bovyer, . . .	Charlottetown, P.E.I.	Slaymaker & Son, .	Wyoming, Del.
C. E. Hardy, . . .	Hollis, N. H.	Dr. S. S. Guerrant, .	Callaway, Va.
Edw. Lefavour, . . .	Marblehead, Mass.	G. C. Sheible, . . .	Tiptop, Ky.
Massachusetts Agricultural College, . . .	Amherst, Mass	G. H. & S. G. Ellis, .	Dayton, Tenn.
J. M. Fisk, . . .	Abbottsford, Que.	J. O. Kelley & Sons, .	Jeff, Ala.
T. L. Kinney, . . .	South Hero, Vt.	Joe H. Burton, . . .	Mitchell, Ind.
G. H. Wright, . . .	Middlebury, Vt.	J. C. B. Heaton, . .	New Burnside, Ill.
Wilfred Wheeler, .	Concord, Mass.	Geo. T. Lincoln, . .	Bentonville, Ark.
F. S. Wallbridge, .	Belleville, Ont.	Geo. L. Sipes, . . .	West Fork, Ark.
Connecticut Agricultural College, . . .	Storrs, Conn.	C. S. Bouton, . . .	Springfield, Ark.
New York Experiment Station, . . .	Geneva, N. Y.	G. S. Christy, . . .	Lincoln, Neb.
Wm. Miller, . . .	Gypsum, O.	Kansas State Agricultural College, .	Manhattan, Kan.
U. T. Cox, . . .	Proctorville, O.	Ira Townsend, . . .	Iola, Kan.
Wm. Stewart, . . .	Landisburg, Pa.	J. B. Fergus, . . .	Kincaid, Kan.
F. H. Fasset, . . .	Meshoppen, Pa.	G. B. Prince, . . .	Santa Fé, N. M.
S. H. Derby, . . .	Woodside, Del.	E. F. Cadwallader, .	Mountain Park, N. M.
A. J. Norman, . . .	Harris' Wharf, Md.	Stirling & Pitcairn, .	Kelowna, B. C.

As a rule the samples represent about the best type of the various varieties grown in the different localities. The samples received varied from a half dozen to a barrel, and from these from six to twelve good specimens were selected for analysis. They were ground in a food chopper, and after weighing a sample for sugar determinations, were preserved in a glass jar with formaldehyde. The methods of analysis followed were those of Bulletins 66 and 107 of the Bureau of Chemistry.

The determination of total solids was made by drying 25 grams on pumice in a water oven at 95° to 98° for twenty

to twenty-two hours. This probably gives results too low, but this method seemed the best with the facilities at hand. Insoluble solids were determined by washing 25 grams with 500 cubic centimeters hot water on muslin filters, and drying on pumice fourteen hours at 95° to 98°. The reducing sugars were determined by reducing Fehling's solution and weighing the precipitate as cuprous oxide; the sucrose, by means of the polariscope; and malic acid, by titrating with N/10 alkali with phenolphthalein as an indicator.

Most of the analyses were made during the winter of 1910-11. All samples, save those from Amherst, were shipped direct to cold storage in Holyoke, Mass., and transferred to Amherst a few samples at a time, as needed, where they were held as cool as possible. The Amherst samples, as well as all those of 1910, were kept in an excellent cellar storage at the college. The laboratory numbers were given in order of analysis, work being begun with No. 1 in November, 1910, and completed about March 1, 1911. The samples of 1910 were analyzed in March, and while no notes of their condition were taken, it can be said that they were in excellent condition, most of them eating ripe.

These analyses form the basis for the chemical side of the discussions of the different varieties in this paper. There are, however, certain questions not dealt with elsewhere which may receive consideration at this point.

Nearly all the differences in analyses between the different samples, aside from those fairly attributable to the unavoidable errors of sampling and analysis, can be traced to one of two causes: (1) varietal differences; these are brought out in Table 1; (2) those attributable to different stages of maturity of the fruit. The chemical changes occurring in the growth and ripening of the apple are clearly brought out in the work of the Bureau of Chemistry, reported in Bulletin 94 of the Bureau, and the reader is referred to that publication for a discussion of this question. During the past winter analyses were made of four samples in November and again in February. These were: —

	November.	February.		November.	February.
Greening, . . .	No. 4	No. 93	Baldwin, . . .	No. 2	No. 97
Baldwin, . . .	No. 1	No. 98	McIntosh, . . .	No. 27	No. 102

Reference to the analyses of these samples will show that they are in entire accordance with the results reported in the above-mentioned publication. A study of the figures given shows that, as a rule, varieties grown to the north of their natural range exhibit the characteristics of immature fruits. The analysis of the Ben Davis, sample 91, indicates an apple that failed to mature on the tree, and has gone down in storage after the manner of immature fruit. In general, the analysis of this variety shows that the more northern-grown specimens are low in solids and sugars and high in insoluble solids and acid, and the same is generally true of the other varieties.

TABLE 7. — *Chemical Determinations.*

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
<i>Wealthy.</i>											
Charlottetown, P. E. I., .	19	14.97	1.74	13.23	8.81	1.78	10.59	.60	75×60	40 to 60 per cent. striped and splashed; some blush on sunny side.	Rather poor; lacks Wealthy flavor; very slightly astringent.
Amherst, Mass., .	28	13.38	2.20	11.18	6.91	1.98	8.89	.44	Medium and below	Fair.	Ripe, or a little past; flavoring oils deficient; slightly mealy.
Storrs, Conn., .	6	12.97	2.29	10.68	6.47	1.36	7.83	.46	65×52	Fair; well covered, but not intense.	Rather flat; lacks flavor; may be over-ripe.
<i>Wolf River.</i>											
Charlottetown, P. E. I., .	16	14.81	3.05	11.76	5.84	6.61	12.45	.72	85×65	Poor to good.	Poor; lacks flavor; astringent; immature and overripe.
Kincaid, Kan., .	72	14.24	2.49	11.75	8.93	.85	9.78	.44	87×66	Pale; poorly covered; pale stripes.	Fair; slightly acid; somewhat mealy.
Mountain Park, N. M., .	14	12.59	2.49	10.10	6.22	3.82	10.04	.74	Medium	Good; nearly blushed; slightly pinkish.	Not equal to those of north; lacks flavoring oils; slight musty flavor.
<i>Maiden Blush.</i>											
Storrs, Conn., .	5	13.23	2.10	11.13	3.95	2.43	6.38	.50	70×53	Good; one-third blushed.	A little flat; perhaps a little overripe; slightly astringent; lacks flavor.
Callaway, Va., .	12	15.39	3.06	12.33	5.05	4.14	9.19	.72	Medium	Greenish; dull red.	Good; better than No. 10; not mealy.
Tip Top, Ky., .	10	15.15	2.83	12.32	5.39	2.85	8.24	.67	Medium	Good; one-third blushed.	Slightly overripe; better than No. 5.
Springdale, Ark., .	11	13.34	2.74	10.60	5.73	1.29	7.02	.35	Medium	Dull; poorer than No. 10.	Overripe; somewhat astringent; mealy; lacks acid.

TABLE 7. — *Chemical Determinations* — Continued.

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
<i>Fameuse.</i>											
Charlottetown, P. E. I., .	13	15.76	2.85	12.91	7.88	.99	8.87	.47	Small	Green; one third dull red.	Fair; rather acid and lacks oils; very thick skin.
Abbotsford, Que., .	44	14.36	2.50	11.86	7.81	1.72	9.53	.19	64×53	Fair to good.	Good.
Storrs, Conn., .	7	14.87	2.32	12.55	6.06	1.64	7.70	.41	68×58	Fair to good; deep dull red.	Fair; somewhat flat; not equal to more northern grown; a little past.
Landisburg, Pa., .	71	15.21	2.33	12.88	9.63	.49	10.12	.23	68×64	Fair; not intense.	Were fair; now overripe; not acid.
Gypsum, O., .	46	15.80	2.79	13.01	8.84	1.34	10.18	.45	Small	Fair.	Good, ripe, or a little past.
Santa Fé, N. M., .	18	14.65	2.75	11.90	8.00	.91	8.91	.43	68×53	Rather pale, blushed and striped.	Fair; lacks Fameuse flavor; not much acid.
<i>McIntosh.</i>											
Charlottetown, P. E. I., .	15	15.40	2.21	13.19	6.80	1.19	7.99	.43	Small; roundish	Green and dull red.	Poor; lacks oils; good texture; slightly astringent.
Abbotsford, Que., .	45	14.26	2.38	11.88	7.09	3.44	10.51	.45	68×60	Very good; deep, rich blush.	Good; ripe; possibly a trifle astringent.
Amherst, Mass., .	27	14.77	2.38	12.39	8.17	2.74	10.91	.38	Medium or above	Fair.	Very good; flavoring oils a little low.
Amherst, Mass., .	102	13.59	2.30	11.29	8.26	1.07	9.33	.31	76×57	Fair.	Much overripe; lacks flavor and body; still juicy.
Geneva, N. Y., .	9	15.05	2.21	12.84	9.90	2.68	12.58	.35	66×54	Striped and blushed; good.	More aromatic and tender than No. 8.
Storrs, Conn., .	8	14.10	2.42	11.68	5.50	2.14	7.64	.39	76×66	Fair to good.	Fair; perhaps a little overripe.
Bitter Root Valley, Mont., .	103	13.30	2.42	10.88	7.41	1.61	9.02	.29	Below medium	Very good.	Not equal to No. 27; seems astringent; perhaps picked immature.
<i>Jonathan.</i>											
Ghent, N. Y., .	105	15.60	2.68	12.92	9.39	.31	9.81	.40	67×56	Fair though not equal to best.	Good; lacks body; barely ripe.
Wyoming, Del., .	49	15.71	2.35	13.36	8.05	2.60	10.65	.42	72×62	Fair.	-

	24	14.42	2.21	12.21	8.43	1.52	9.95	.42	70×58			
Proctorville, O.,	.	.	2.21	12.21	8.43	1.52	9.95	.42	68×62	Fair; 40 per cent. over color.	Good, but not as rich as No. 23; less mature.	
Moran, Kan.,	73	15.88	2.20	13.68	9.88	.00	9.88	.34		Very good.	Good; prime condition.	
Kincaid, Kan.,	80	14.35	2.23	12.12	9.66	.61	10.27	.31	71×58	Fair, not very deep.	Good; fully ripe or a little past.	
Tip Top, Ky.,	29	16.18	2.70	13.48	9.00	1.98	10.98	.60	Small	Deep, dull red.	Fair to good.	
Mountain Park, N. M.,	23	15.68	2.30	13.38	8.35	3.42	11.77	.55	73×64	Very good; waxy yellow and deep red.	Good; slightly acid; eating ripe.	
Hood River, Ore.,	106	13.83	2.23	11.60	8.16	1.34	9.50	.36	73×61	Good, about like No. 105.	Very good; more tender than No. 105; variable.	
Ghent, N. Y.,	1910	13.97	2.35	11.62	5.36	2.40	7.76	.39	-	-	-	
Kelowna, B. C.,	1910	16.24	2.58	13.66	6.48	2.40	8.88	.50	-	-	-	
<i>Esopus Spitzenburg.</i>												
Cornwall, Conn.,	1910	16.51	2.54	13.97	6.81	3.10	9.91	.49	-	-	-	
Hood River, Ore.,	1910	19.07	2.79	16.28	7.18	4.22	11.40	.62	-	-	-	
<i>Grimes.</i>												
Storrs, Conn.,	109	14.97	2.55	12.42	6.71	2.98	9.69	.39	69×64	Good; considerable russet.	Good, but not equal to No. 108; ripe.	
Gypsum, O.,	48	18.66	3.04	15.62	5.36	5.43	10.79	.47	67×56	Fair to good; some russet.	-	
Proctorville, O.,	22	17.84	2.52	15.32	8.40	3.34	11.74	.34	71×58	Good; yellow; some russet.	Good, better than No. 21; very slightly acid.	
Landisburg, Pa.,	70	14.33	2.24	12.09	7.08	3.50	10.58	.31	75×66	Fair to good; not clear and bright.	Good; more acid and not as rich as No. 68 and No. 69.	
Wyoming, Del.,	50	17.58	2.81	14.77	5.81	4.71	10.52	.64	80×65	Good, slightly russetting.	Excellent; prime condition.	
Mitchell, Ind.,	68	15.95	2.50	13.45	8.35	4.24	12.59	.24	76×67	Excellent; clear, rich yellow.	Excellent; fully ripe; sweetish.	
Tip Top, Ky.,	21	19.87	3.07	16.70	8.35	5.54	13.89	.50	66×54	Good; very slightly russet.	Fair; lacks flavoring oils; slightly overripe.	
Moran, Kan.,	69	16.62	2.48	14.14	8.39	3.46	11.85	.28	74×62	Very good.	Good; slightly wilted; a little overripe.	
Kelowna, B. C.,	108	15.40	2.42	12.98	6.86	2.98	9.84	.34	71×65	Excellent; clear straw-yellow.	Excellent; crisp; mild subacid; just ripe.	
Storrs, Conn.,	1910	16.00	2.84	13.16	6.53	2.97	9.50	.39	-	-	-	
Kelowna, B. C.,	1910	16.68	2.65	14.03	7.82	3.38	11.20	.29	-	-	-	

TABLE 7. — *Chemical Determinations* — Continued.

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
<i>King.</i>											
Amherst, Mass., . . .	26	15.20	2.53	12.67	8.61	2.06	10.67	.35	Medium	Rich, yellow, fair over-color.	Good; ripe, or a little past.
Gypsum, O., . . .	35	17.75	2.36	15.39	8.25	2.71	10.96	.41	82×72	Good, somewhat russeting.	Very good; clear, mild subacid; somewhat mealy; a little overripe.
<i>Rhode Island Greening.</i>											
Amherst, Mass., . . .	4	15.29	2.68	12.61	3.91	4.07	8.01	.62	Large	Good, yellow-green.	Good, though not very rich.
Amherst, Mass., . . .	93	14.23	2.91	11.32	6.04	1.42	7.46	.52	84×65	Good, yellow-green.	Very good; slightly past time.
Gypsum, O., . . .	53	16.25	3.12	13.13	6.45	3.88	10.33	.75	80×53	Good, greenish.	Very good; not very acid; eating, ripe.
Landisburg, Pa., . . .	75	17.51	2.86	14.65	7.98	3.71	11.69	.48	80×64	Good, deeper yellow than No. 74.	Good, better than No. 74; richer and sweeter.
Kincaid, Kan., . . .	74	15.05	2.68	12.37	7.48	1.77	9.25	.38	85×65	Good, clear yellowish-green.	Fair; not up to best; possibly a little overripe.
<i>Northern Spy.</i>											
Port Williams, N. S., . . .	1910	16.80	2.62	14.18	6.91	3.42	10.33	.43	-	-	-
Charlottesville, P. E. I., . . .	86	14.22	2.98	11.24	8.48	1.42	9.90	.59	72×62	Fair; 20 per cent. striped and splashed.	Poor; lacks Spy flavor; slightly astringent.
Middlebury, Vt., . . .	101	14.47	2.28	12.19	7.88	2.30	10.18	.44	86×74	Very good.	Good; more crisp than No. 100; a little better flavor.
Concord, Mass., . . .	87	14.51	2.14	12.37	9.14	1.53	10.67	.32	81×69	Good; 30 to 40 per cent. covered.	Very good; perhaps a trifle past prime.
Amherst, Mass., . . .	95	13.94	2.46	11.48	8.04	.00	8.04	.38	78×67	Rich yellow; over-color not best.	Fair to good; full ripe.
Meshoppen, Pa., . . .	54	15.80	2.21	13.59	7.84	2.86	10.70	.46	96×76	Good, but not brightest.	Good; lacks oils; not up to best.
Johnson, Neb., . . .	30	14.37	2.34	12.03	8.47	1.98	10.45	.44	Above medium	Good; yellow; over-color pale and scant.	Poor; lacks oils, sugars and acid; flat.

TABLE 7. — *Chemical Determinations* — Continued.

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
<i>Winesap</i> — Con.											
Manhattan, Kan., . . .	31	17.51	2.85	14.66	9.02	3.35	12.37	.63	Small	Deep; not very bright.	Good; ripe.
Jeff, Ala., . . .	59	15.70	2.61	13.09	9.75	.08	9.83	.42	68×57	Fair, pale.	Poor; lacks flavor; much overripe.
<i>Slayman Winesap</i> .											
Wyoming, Del., . . .	62	16.14	2.39	13.75	7.11	4.52	11.63	.43	80×70	Well covered, but dull.	Extremely good; tender, juicy, sub-acid.
Woodside, Del., . . .	63	16.39	3.05	13.34	8.98	2.56	11.54	.70	68×58	Fair, not intense.	Fair to good; not so rich as No. 62; more acid.
Harris Wharf, Md., . . .	99	14.97	2.12	12.85	8.25	3.25	11.50	.42	79×69	Fair to good; some russet.	Very good; crisp, tender, juicy.
<i>Rome Beauty</i> .											
Gypsum, O., . . .	56	15.51	2.87	12.64	6.32	3.29	9.61	.43	80×69	Good; yellow, green and bright red (one-third to two-thirds).	Fair; seems undeveloped but ripe.
Iola, Kan., . . .	77	13.90	2.63	11.27	6.69	2.72	9.41	.30	85×66	Rich straw-yellow and pale red (30 to 40 per cent.).	Overripe; mealy; not good.
West Fork, Ark., . . .	90	17.75	3.18	14.57	7.30	3.48	10.78	.51	Medium	Good; well covered; fairly bright.	Not good; lacks flavor; mealy; probably overripe, though firm.
<i>Smith Cider</i> .											
Landisburg, Pa., . . .	89	17.96	3.56	14.40	7.02	2.37	9.39	.57	81×71	Good; 50 to 60 per cent. covered; fairly bright.	Pretty good; a little overripe.
Kincaid, Kan., . . .	88	16.78	3.05	13.73	8.05	2.37	10.42	.44	84×68	Fair, a little pale.	Extremely poor; far overripe; very dry and mealy.

<i>Roxbury Russet.</i>											
Amherst, Mass.,	104	18.42	2.94	15.48	7.42	.84	8.28	.66	77×59	Good.	Very good; prime condition.
Proctorville, O.,	43	19.55	2.72	16.83	9.65	4.19	13.84	.40	73×57	Good; well russeted.	Good, somewhat wilted; ripe, or a little past.
Wyoming, Del.,	61	17.93	2.49	15.44	6.52	7.64	14.16	.70	77×58	Good, deep, even russet.	Fair to good.
Amherst, Mass.,	1910	19.03	3.14	15.89	6.96	5.93	12.89	.60	-	-	-
<i>York Imperial.</i>											
Amherst, Mass.,	96	14.38	2.89	11.49	7.67	.46	8.13	.41	78×62	Good, yellow, overcolor pale and scant.	Fair; just about ripe.
Landisburg, Pa.,	81	15.13	2.62	12.51	8.57	1.65	10.22	.37	81×65	Excellent; rich; fairly deep red.	Good, firm and crisp; just ripe; sweetish.
Wyoming, Del.,	25	15.60	2.84	12.76	7.78	2.66	10.44	.39	78×68	Good; straw-yellow; overcolor scanty.	Fair, firm and crisp; very nearly ripe.
Woodside, Del.,	57	16.02	2.70	13.32	7.28	4.01	11.29	.28	88×78	Good; fairly bright; not intense.	Good; very juicy; sweetish; barely ripe; crisp.
Dayton, Tenn.,	35	16.47	2.76	13.71	7.61	3.22	10.83	.42	79×58	Good.	Very good; just ripe.
Johnson, Neb.,	36	17.62	2.85	14.77	7.45	3.78	11.23	.49	78×68	Good.	Very good; just ripe.
Manhattan, Kan.,	37	16.20	2.45	13.75	8.68	3.40	12.08	.41	74×63	Good; a little rusty.	Very good; ripe; crisp.
Kincaid, Kan.,	79	15.81	2.59	13.22	8.55	2.53	11.08	.38	80×66	Very good; nearly covered; rich red.	Good; prime condition; not as crisp as some.
<i>Yellow Newtown.</i>											
Milton-on-Hudson, N. Y.,	1910	17.25	2.66	14.59	7.38	3.13	10.51	.42	-	-	-
Hood River, Ore.,	1910	15.70	2.83	12.87	7.79	3.00	10.79	.51	-	-	-
<i>Ben Davis.</i>											
Charlottetown, P. E. I.,	91	15.78	4.28	11.50	7.07	.46	7.53	.54	63×58	Poor; 25 to 40 per cent. covered.	Very poor; green; astringent; hard.
Abbotsford, Que.,	67	14.38	3.34	11.04	6.28	2.26	8.69	.39	66×55	Poor; not well covered.	Not ripe; about like No. 66.
Marblehead, Mass.,	66	14.21	3.61	10.60	7.24	2.41	9.50	.42	65×58	Poor; not well covered.	Not yet ripe; poor; slightly astringent; acid; tough.
Amherst, Mass.,	92	15.08	4.02	11.06	5.64	1.87	7.51	.61	75×66	Good.	Fair to good; perhaps not quite ripe.
Belleville, Ont.,	39	17.51	3.60	13.91	7.65	3.23	10.88	.42	70×58	Good.	Fair to good; not ripe; flesh greenish.

TABLE 7. — *Chemical Determinations* — Concluded.

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
<i>Ben Davis</i> —Con.											
South Haven, Mich.,	82	15.21	3.39	11.82	6.25	2.98	9.23	.44	70×65	Fair; 25 to 40 per cent. covered.	Fair; ripe.
Gypsum, O.,	65	16.53	3.28	13.25	7.46	3.32	10.78	.51	67×57	Fair; not well covered.	A little riper than No. 64; hardly as acid.
Mitchell, Ind.,	83	13.88	2.77	11.11	5.75	1.53	7.28	.45	80×68	Very good; all covered, striped.	Very good; prime condition.
Wyoming, Del.,	64	15.57	3.20	12.37	6.77	3.35	10.02	.52	78×62	Very good; not well covered.	Not quite ripe; promises good.
Johnson, Neb.,	38	15.31	2.68	12.63	6.53	3.46	9.99	.51	81×65	Excellent.	Excellent; just ripe; flesh white.
Manhattan, Kan.,	42	15.42	2.89	12.53	6.98	3.34	10.32	.39	74×61	Good.	Good; a little more acid than No. 41.
Kineaid, Kan.,	84	15.17	2.88	12.29	6.88	3.59	10.47	.41	81×70	Very good; like No. 83.	Very good; equal or better than No. 63.
Springdale, Ark.,	40	15.46	3.06	12.40	7.29	1.67	8.96	.43	77×66	Fair; slightly pinkish.	Good; ripe, lacks flavoring oils; flesh white.
Bentonville, Ark.,	41	15.64	2.86	12.78	7.44	2.35	9.79	.29	75×65	Good.	Very good; flesh white.
West Fork, Ark.,	85	16.53	3.13	13.40	6.95	3.71	10.66	.47	Above medium	Good; dark but dull.	Mealy and dry; overripe.

VII. SUMMARY.

Some of the more important results of this work may be summarized as follows: —

1. The many variations in apple varieties arise from many causes, which may be grouped as (1) cultural, using the word in a broad sense; (2) soil; and (3) climatic. Of climatic influences, temperature is the most potent.

2. The life history of the apple may for convenience in discussion be divided into four periods: (1) growth, extending from the blossom to the attainment of full size; (2) ripening, extending to the time of harvest; (3) after ripening, extending to complete edible maturity; and (4) decay, covering the period of physiological breaking down.

3. The apple of superior table quality is high in sugars, especially sucrose, and low in insoluble solids, indicating a tender flesh and fine texture. The acid is proportionate to sugars; the ratio may vary somewhat to accord with different tastes. Good kitchen apples are wider in ratio of sugars to acid, and the proportion of insoluble solids is of little significance. Good shipping apples are high in insoluble solids.

4. In any variety of apples, high development at full maturity is marked by the attainment of full normal size for the variety, high color, well spread over the apple, and a high development of sugars, especially sucrose.

5. Each variety has a characteristic chemical composition, fairly constant when perfect maturity is attained. Most of the differences found in different samples of a variety are due to a difference in the stage of development reached.

6. The fruit of individual trees shows slight differences in size, color, form and abundance that are characteristic and not due to environmental conditions. Some of this may be due to bud variation, but it is believed that most of it is due to the interrelation of stock and scion.

7. Variation in form in the Ben Davis, and probably in other sorts as well, is due principally to the temperature during a period of about two or three weeks following blossoming. The lower the temperature the more elongated the apple. This elon-

gation is seen in apples grown near large bodies of water, which lower the temperature at this season of the year, and in seasons when the temperature is low owing to seasonal fluctuations. This influence is also seen in the form of apples in different parts of the tree. Those in the lower north portion are more elongated than those from the warmer, upper south portion.

8. Seasonal temperature affects the size of apples, a cool season resulting in smaller fruit. This is marked only in full-season varieties, and is especially noticeable in the more northerly portions of their distribution. On the other hand, in the extreme south a variety is apt to be smaller than when grown in a somewhat cooler climate.

9. For convenience in discussion, North America may be divided into seven apple belts, each having a fairly characteristic list of varieties. These are named and illustrated in the text.

10. Some varieties are of wide distribution; others more or less limited. Varietal qualities favoring a wide distribution are (1) great hardiness of tree, (2) a short season of development, (3) great vigor and ability to thrive under generally unfavorable conditions, (4) productiveness and good market qualities.

11. The northern limit of apple growing is fixed by the minimum winter temperature, and the southern limit by the heat of the hottest part of the summer, occurring usually in July or August.

12. The attainment of the highest quality, appearance and keeping quality is very largely dependent on the warmth and length of the growing season. This may be measured with fair satisfaction for the apple-growing regions of North America by an average of the mean temperatures for the months of March to September inclusive. This is called the mean summer temperature, and give temperatures ranging from 52° to 72°.

13. Factors determining the mean summer temperature in a given orchard are (1) latitude, (2) elevation, (3) site and aspect, (4) soil, (5) culture, (6) prevailing winds, (7) sunshine.

14. The optimum mean summer temperature for different varieties may be determined with fair satisfaction, and some deter-

minations are shown in Table 5. A departure of over 2° from this mean will result in less desirable fruit, though this may not be marked in short-season varieties.

15. A summer mean too low for a variety results in (1) greater acidity, (2) increased insoluble solids, (3) greater astringency, (4) less coloration, (5) decreased size, (6) scalding in storage.

16. A summer mean too high for a variety results in (1) uneven ripening, (2) premature dropping, (3) rotting on the trees, (4) poor keeping quality, (5) lack of flavor, (6) "mealiness," (7) less intense color (8) decreased size.

COMPILATIONS.

INTRODUCTION.

BY J. B. LINDSEY.

A compilation of the chemical composition of fodder articles, agricultural chemicals and manurial residues was first made by Prof. C. A. Goessmann and his assistants in 1887, and published in the fifth report of the Massachusetts State Agricultural Experiment Station, pages 181–227. This compilation included all analyses made by Goessmann and his co-workers since 1868. It was later enlarged to include compilations of the analyses made at this station of dairy products, fruits, garden crops and insecticides. The parties largely responsible for the details of the several compilations were W. H. Beal, C. S. Crocker, J. B. Lindsey, H. D. Haskins, E. B. Holland and P. H. Smith. In 1896 the classification of fodder articles was considerably modified and improved; the present compilation of agricultural chemicals and manurial residues has undergone a similar rearrangement, and the available analyses have been added to the compilation of fruits and garden crops. Naturally a few materials, being no longer of interest, have been omitted.

The tables of compilations are as follows:—

- Table I. Composition and Digestibility of Fodder Articles, pp. 247–265.
Table II. Fertilizer Ingredients of Fodder Articles, pp. 266–271.
Table III. Analyses of Dairy Products, p. 272.
Table IV. Coefficients of Digestibility of American Fodder Articles, pp. 273–303.
Table V. Analyses of Agricultural Chemicals, etc., pp. 304–323.
Table VI. Analyses of Fruit and Garden Crops, pp. 324–338.

COMPILATION OF ANALYSES OF FODDER ARTICLES AND DAIRY PRODUCTS, MADE AT AMHERST, MASS., 1868-1910.¹

P. H. SMITH AND J. B. LINDSEY.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES.

- I. Green fodders.
 - (a) Meadow grasses and millets.
 - (b) Cereal fodders.
 - (c) Legumes.
 - (d) Mixed and miscellaneous.
- II. Silage.
- III. Hay and dry, coarse fodders.
 - (a) Meadow grasses and millets.
 - (b) Cereal fodders.
 - (c) Legumes.
 - (d) Straw.
 - (e) Mixed and miscellaneous.
- IV. Vegetables, fruits, etc.
- V. Concentrated feeds.
 - (a) Protein.
 - (b) Starchy.
 - (c) Poultry.

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES.

TABLE III. — ANALYSES OF DAIRY PRODUCTS.

EXPLANATION OF TABLE I.

Under *composition* the figures mean that each 100 pounds of the fodder contains so many pounds of water, protein, fiber, etc.

Water. — The approximate average which is likely to occur in the material is stated.

Ash refers to the residue which is left behind when the material is burned, and consists of lime, potash, soda, magnesia, iron, phosphoric and sulfuric acids.

Protein is a collective name for all of the nitrogenous matter; it corresponds to the lean meat in the animal, and may be termed

¹ Part III. of the report of Department of Plant and Animal Chemistry.

“vegetable meat.” It serves as the exclusive source of flesh, as well as a source of heat or energy, and fat.

Fiber is the coarse or woody part of the plant. It may be called the plant’s framework. It is a source of heat or energy and fat.

Nitrogen-free extract represents the sugars, starches and gums. It is the principal source of heat or energy and fat.

Fat includes not only the various oils and fats in all grains and coarse fodders, but also waxes, resins and coloring matters. It is also termed ether extract because it is that portion of the plant soluble in ether. It serves as a source of heat or energy and body fat.

Under *digestibility* the figures mean that so many pounds of protein, fiber, nitrogen-free extract and fat in 100 pounds of the fodder are actually digested and made use of by the animal. No feed is entirely digestible; concentrates are more digestible than coarse fodders. The data under digestibility have been worked out by actual experiment. In cases where no figures appear, data as a result of experiments are lacking.

Net Energy Value.—The entire amount of heat or energy contained in a feeding stuff is termed its total heat or energy value. All of this heat or energy cannot be utilized by the animal for the purposes of maintaining its body in a state of equilibrium, or for aiding in the production of growth and milk. The several losses may be enumerated as follows: (a) the undigested material, *i.e.*, the fæces; (b) the incompletely used material of the urine; (c) the work required in the processes of digestion and assimilation in preparing the nutrients so that they can be used for maintenance and for the production of growth and milk. These several sources of loss expressed as energy, deducted from the total energy, leaves the real or *net energy value*.

The calorie is the unit of energy measurement.

The small calorie represents the amount of heat required to raise 1 gram of water 1° C.

The large calorie represents the amount of heat necessary to raise 1 kilogram (1,000 grams) of water 1° C.

The therm, a name proposed by Armsby, represents the amount of heat required to raise 1,000 kilograms of water 1° C. It is to be preferred to the small or large calorie as a unit of measurement because it can be expressed in fewer figures.

In the last column of the following table, headed net energy value, is given the number of therms contained in 100 pounds of the different feeding stuffs, based on the results of very carefully conducted experiments by Kellner, a German investigator.¹

¹ For a full explanation of the components of the animal body, the composition of feeds, the different ways in which the food is used in the animal body and the explanation for using the therm in the calculation of rations for farm animals, see Farmers’ Bulletin 346, United States Department of Agriculture, prepared by H. P. Armsby.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES.

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
I. GREEN FODDERS.												
(a) Meadow Grasses and Millets.												
Johnson grass (<i>Andropogon halepensis</i>),	1	75	1.4	1.2	8.9	13.2	0.3	-	-	-	-	-
Orchard grass (<i>Dactylis glomerata</i>),	7	70	2.1	2.9	10.4	13.7	0.9	-	-	-	-	-
Tall oat grass (<i>Arrhenatherum elatius</i>),	4	70	1.6	2.3	10.8	14.7	0.6	-	-	-	-	-
Common millet (<i>Chenopodium italicum</i>),	16	80	1.0	1.5	6.5	10.5	0.5	0.9	4.6	7.0	0.31	9.9
Canary bird seed millet (<i>C. Italica</i>),	1	80	1.6	1.0	7.1	10.0	0.3	-	-	-	-	-
Early harvest millet (<i>C. Italica</i>),	1	80	1.4	1.1	7.4	9.7	0.4	-	-	-	-	-
Golden millet (<i>C. Italica</i>),	1	80	1.2	0.8	7.0	10.7	0.3	-	-	-	-	-
Hungarian grass (<i>C. Italica</i>),	3	80	1.4	1.9	5.8	10.5	0.4	1.2	4.1	7.0	0.2	9.9
Japanese millet (<i>C. Italica</i>),	12	80	1.2	1.7	6.2	10.5	0.4	0.9	3.8	7.0	0.3	9.4
Millet (<i>Panicum mitaceum</i>),	1	80	1.1	1.1	5.3	11.7	0.8	-	-	-	-	-
Broom-corn millet (<i>P. mitaceum</i>),	1	80	1.2	1.3	6.4	10.7	0.4	-	-	-	-	-
Hog millet (<i>P. mitaceum</i>),	1	80	1.4	1.5	6.5	10.2	0.4	-	-	-	-	-
Japanese broom-corn millet (<i>P. mitaceum</i>),	2	80	1.2	0.9	6.2	11.4	0.3	-	-	-	-	-
Barnyard millet (<i>Panicum crus-galli</i>),	8	80	1.7	1.9	6.6	9.4	0.4	1.2	4.8	6.7	0.2	9.9

1 Same coefficients used as for Hungarian grass.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*
 [Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therm. Val.)	
		Water.	Ash.	Protein.	Fiber.	Nitrogen free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.		
I. GREEN FODDERS — Con.													
(a) Meadow Grasses and Millets — Con.													
Pearl millet (<i>Pennisetum spicatum</i>),	1	80	1.4	1.4	6.9	10.1	0.2	-	-	-	-	-	-
Japanese millet (variety uncertain),	3	80	1.1	1.2	7.1	10.2	0.4	0.6	4.4	6.8	0.3	8.8	8.8
(b) Cereal Fodders.													
Barley,	1	75	2.1	3.2	9.4	9.6	0.7	2.3	5.7	6.8	0.4	10.7	10.7
Barley in milk,	1	75	1.2	2.6	7.3	13.2	0.7	1.8	4.1	9.8	0.3	12.9	12.9
Corn ears (as harvested),	4	70	0.7	2.9	4.0	21.5	0.9	-	-	-	-	-	-
Corn husks (as harvested),	6	80	0.7	1.2	6.0	11.8	0.3	-	-	-	-	-	-
Corn leaves (as harvested),	4	75	2.4	3.6	6.2	12.0	0.8	-	-	-	-	-	-
Corn stalks (as harvested),	4	80	1.0	0.8	6.5	11.5	0.2	-	-	-	-	-	-
Corn fodder, Brewers Dent,	2	80	1.0	2.0	5.0	11.7	0.3	1.4	3.4	9.0	0.2	12.0	12.0
Corn fodder Early Mastodon Dent,	3	80	0.9	1.7	4.6	12.4	0.4	1.0	2.8	9.8	0.3	12.3	12.3
Corn fodder, Klondike,	1	80	1.2	1.1	5.7	11.7	0.3	-	-	-	-	-	-
Corn fodder, Leaming,	5	80	1.0	1.6	4.9	12.1	0.4	1.0	3.0	9.3	0.3	11.8	11.8
Corn fodder, Longfellow,	1	80	1.1	1.8	4.0	12.8	0.3	-	-	-	-	-	-
Corn fodder, Pride of the North,	6	80	0.9	1.7	4.3	12.6	0.5	1.1	2.8	10.2	0.4	13.2	13.2

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*
 [Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therms.).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
I. GREEN FODDERS — <i>Con.</i>												
(c) Legumes — <i>Con.</i>												
Soy bean (medium green),	18	80	2.3	4.1	5.2	7.8	0.6	3.2	2.4	6.0	0.3 ¹	9.7
Soy bean (medium green), in bud,	1	80	2.5	4.2	5.5	7.3	0.5	3.3	2.8	5.3	0.3	9.2
Soy bean (medium green), in blossom,	5	80	2.3	4.0	5.5	7.7	0.5	3.1	2.6	5.5	0.3	9.0
Soy bean (medium green), in pod,	9	78	2.3	4.5	5.9	8.6	0.7	3.5	2.7	6.6	0.4	10.7
Soy bean (medium black),	2	80	2.5	3.8	4.7	8.0	1.0	3.0	2.1	6.2	0.6 ¹	10.3
Soy bean (late),	4	80	2.6	4.6	4.2	8.0	0.6	3.6	1.9	6.2	0.3 ¹	10.4
Clover, alsike (<i>Trifolium hybridum</i>),	8	80	2.3	3.3	5.4	8.5	0.5	—	—	—	—	—
Clover, crimson (<i>T. incarnatum</i>),	2	80	2.8	3.1	6.0	7.6	0.5	2.4	3.4	5.6	0.3	9.0
Clover, mammoth red (<i>T. medium</i>),	4	80	1.9	3.0	5.8	8.9	0.4	—	—	—	—	—
Clover, medium red (<i>T. pratense</i>),	13	80	1.8	3.1	5.7	8.8	0.6	2.0	3.0	6.3	0.4	9.3
Clover, medium red, in bud,	2	80	2.1	3.6	4.7	9.0	0.6	2.4	2.5	6.6	0.4 ²	10.1
Clover, medium red, in blossom,	3	79	1.9	3.5	6.0	9.0	0.6	2.3	3.2	6.5	0.4	9.9
Clover, medium red, seeding,	2	75	2.3	3.8	7.2	11.0	0.7	2.5	3.8	7.9	0.4	10.2
Sweet clover (<i>Melilotus alba</i>),	4	80	1.9	3.8	6.3	7.4	0.6	—	—	—	—	—
Cow pea (<i>Vigna catjang</i>),	12	85	2.0	2.8	3.5	6.3	0.4	2.1	2.1	5.1	0.2 ³	8.1

Cow pea, black,	6	85	2.2	2.8	3.6	6.1	0.3	2.1	2.2	4.9	0.2 ³	8.0
Cow pea, New Era,	1	85	1.9	2.6	3.6	6.4	0.5	2.0	2.2	5.2	0.3 ³	8.3
Cow pea, Whip-poor-will,	7	85	1.9	2.6	3.7	6.5	0.3	2.0	2.2	5.3	0.2 ³	8.9
Canada beauty pea (<i>Pisum arvense</i>),	1	85	1.2	2.4	4.4	6.6	0.4	-	-	-	-	-
Canada field pea (<i>P. arvense</i>),	8	85	1.3	3.2	4.3	5.8	0.4	2.6	2.1	4.4	0.2	8.0
Canada field pea (<i>P. arvense</i>), in bud,	2	85	1.1	3.2	4.1	6.1	0.5	2.6	2.5	4.3	0.3 ⁴	8.0
Canada field pea (<i>P. arvense</i>), in blossom,	3	87	1.2	2.8	3.8	4.8	0.4	2.3	1.7	3.6	0.2	6.1
Canada field pea (<i>P. arvense</i>), in pod,	2	84	1.2	2.3	4.8	6.3	0.4	1.9	2.2	4.8	0.2	6.9
English gray pea (<i>P. arvense</i>),	1	85	1.4	3.1	4.5	5.5	0.5	-	-	-	-	-
Prussian blue pea (<i>P. arvense</i>),	1	85	1.3	2.8	4.5	5.9	0.5	-	-	-	-	-
Flat pea (<i>Lathyrus sylvestris wagneri</i>),	2	85	1.3	4.4	3.7	5.0	0.6	-	-	-	-	-
Sainfoin (<i>Onobrychis sativa</i>),	1	75	2.1	4.4	6.0	11.6	0.9	-	-	-	-	-
Serradella (<i>Orianthopus sativus</i>),	3	85	1.6	2.2	4.4	6.5	0.3	-	-	-	-	-
Sulla (<i>Hedysarum coronarium</i>),	2	75	2.3	4.3	5.2	12.5	0.7	-	-	-	-	-
Spring vetch (<i>Vicia sativa</i>),	4	85	1.4	2.7	4.5	6.1	0.4	1.9	2.0	4.6	0.2	7.8
Winter or sand vetch (<i>Vicia villosa</i>),	7	85	2.1	3.4	4.4	4.7	0.4	2.8	2.8	3.6	0.3	7.5
Winter or sand vetch (<i>V. villosa</i>), in bud,	2	86	2.4	3.3	3.5	4.4	0.4	-	-	-	-	-
Winter or sand vetch (<i>V. villosa</i>), in blossom,	4	82	2.5	4.2	5.5	5.4	0.4	3.5	3.5	4.2	0.3	9.1
Kidney vetch (<i>Anthyllus vulneraria</i>),	1	85	2.0	2.8	2.3	7.4	0.5	-	-	-	-	-
(d) Mixed and Miscellaneous.												
Barley and peas,	1	80	1.6	2.8	6.8	8.2	0.6	2.1	3.5	5.6	0.4	8.5
Barley and vetch,	2	80	1.2	2.8	6.5	9.0	0.5	2.1	3.4	6.1	0.3 ⁵	8.9

¹ Same coefficients applied to all soy beans except to medium green varieties in different stages of growth.

² Coefficients taken from the German.

³ Same coefficients applied to all cow peas. ⁴ Same coefficients applied to Canada field peas in blossom and in pod. ⁵ Same coefficients used as for barley and peas.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therms).	
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.		
I. GREEN FODDERS — <i>Con.</i>													
(d) <i>Mixed and Miscellaneous</i> — <i>Con.</i>													
Corn and soy bean,	3	80	1.5	2.6	5.0	10.4	0.5	-	-	-	-	-	-
Corn and cow peas,	1	80	1.8	2.1	5.3	10.4	0.4	-	-	-	-	-	-
Sweet corn and cow peas,	4	80	1.7	1.7	5.2	10.9	0.5	-	-	-	-	-	-
Millet and peas,	1	80	1.8	2.4	7.5	8.0	3.0	-	-	-	-	-	-
Tall oat grass and alsike clover,	2	80	1.5	2.7	5.8	9.5	0.5	-	-	-	-	-	-
Orchard grass and alsike clover,	1	80	1.5	2.4	6.5	9.0	0.7	-	-	-	-	-	-
Peas and oats,	4	80	1.7	2.9	6.0	8.8	0.6	2.1	3.8	6.3	0.4	10.0	10.0
Sorghum and cow peas,	1	80	1.6	1.6	6.5	9.9	0.4	-	-	-	-	-	-
Vetch and oats (1-1),	3	80	1.8	3.0	6.3	8.4	0.5	2.3	4.3	5.7	0.2	9.6	9.6
Vetch and oats (1-4),	1	80	1.8	2.7	6.0	8.8	0.7	-	-	-	-	-	-
Wheat and vetch,	4	80	1.6	3.4	6.4	8.1	0.5	2.6	4.4	5.9	0.3	10.4	10.4
Apple pomace,	6	83	0.6	1.0	2.9	11.6	0.9	-	1.9	9.9	0.4	11.7	11.7
Sugar beet pulp,	1	90	0.1	1.4	2.5	5.9	0.1	0.9	2.1	5.0	-	-	-
Cabbage waste,	1	82	4.9	3.6	2.6	6.6	0.3	-	-	-	-	-	-

[illegible]

II, SILAGE.

III. HAY AND DRY COARSE FODDERS.

(a) *Meadow Grasses and Millets.*

4 Same coefficients applied to all varieties of rape.

² Same coefficients used as for fresh apple pomace.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — Continued.

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therms.).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
III. HAY AND DRY COARSE FODDERS — Con.												
(a) Meadow Grasses and Millets — Con.												
Meadow fescue (<i>Festuca elatior pratensis</i>),	7	14	7.1	5.8	32.2	39.3	1.6	3.0	21.6	23.2	0.9	30.3
Barnyard grass (<i>Panicum crus-galli</i>),	1	14	8.6	13.1	29.0	33.6	1.7	-	-	-	-	-
Barnyard millet (<i>P. crus-galli</i>),	8	14	7.3	8.2	28.4	40.4	1.7	5.2	17.6	21.0	0.8	30.7
Hungarian grass (<i>Chenopodium italicum</i>),	3	14	6.3	8.4	24.6	45.0	1.7	5.0	16.7	30.2	1.1	42.4
Orchard grass (<i>Dactylis glomerata</i>),	7	14	5.9	8.3	29.9	39.3	2.6	5.0	18.2	21.6	1.4	32.1
Tall oat grass (<i>Arrhenatherum elatius</i>),	4	14	4.6	6.4	30.9	42.1	1.9	3.3	17.0	24.4	1.1	30.8
Red top (<i>Agrostis alba vulgaris</i>),	6	14	4.6	6.5	28.5	44.9	1.5	4.0	17.4	27.8	0.8	36.6
Red top (<i>A. alba vulgaris</i>), early cut,	1	14	4.3	5.8	30.9	43.3	1.7	-	-	-	-	-
Red top (<i>A. alba vulgaris</i>), late cut,	1	14	4.1	6.0	31.0	43.2	1.7	-	-	-	-	-
Rowen,	32	14	6.5	11.4	24.1	41.0	3.0	7.9	15.9	26.2	1.4	41.1
Italian rye grass (<i>Lolium italicum</i>),	4	14	6.4	7.1	28.6	42.2	1.6	-	-	-	-	-
Perennial rye grass (<i>Lolium perenne</i>),	4	14	7.9	10.1	25.4	40.5	2.1	-	-	-	-	-
Black grass (<i>Juncus Gerardi</i>),	3	16	7.4	7.0	24.3	43.1	2.2	4.1	14.3	22.4	1.0	28.7
Branch grass (<i>Distichlis spicata</i>),	2	16	7.6	6.8	22.4	45.1	2.1	3.8	12.1	22.1	0.7	28.1
Flat sage (<i>Spartina stricta maritima</i> var.),	1	16	8.2	6.6	25.0	41.8	2.4	3.4	15.0	23.0	0.9	30.6

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*
 [Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therms.).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
III. HAY AND DRY COARSE FODDERS — <i>Con.</i>												
(d) <i>Straw.</i>												
Barley,	2	15	4.8	6.5	32.2	39.0	2.5	1.3	18.0	21.1	1.1	25.5
Horse bean,	1	15	8.1	8.3	35.2	32.1	1.3	-	-	-	-	-
Soy bean,	3	15	6.1	4.7	36.1	36.3	1.8	2.4	13.7	24.0	1.1	31.2
Millet (<i>Chenopodia Italica</i>),	1	15	5.3	3.6	35.2	39.5	1.4	-	-	-	-	-
Millet (<i>Panicum crus-galli</i>),	1	15	4.6	5.2	30.4	42.7	2.1	-	-	-	-	-
Millet (<i>P. miliaceum</i>),	1	15	5.2	3.3	35.9	38.1	2.5	-	-	-	-	-
Millet (variety uncertain),	1	15	5.8	4.2	35.5	38.3	1.2	-	-	-	-	-
Wheat,	1	15	4.1	6.2	30.5	42.8	1.4	0.7	15.9	16.3	0.4	17.2
(e) <i>Mixed and Miscellaneous.</i>												
Hairy lotus,	2	15	7.0	12.6	16.8	46.1	2.5	-	-	-	-	-
Oat grass and alsike clover,	2	15	6.5	11.6	24.5	40.1	2.3	-	-	-	-	-
Orchard grass and alsike clover,	1	15	6.6	10.1	27.6	38.3	2.4	-	-	-	-	-
Peas and oats,	4	15	7.2	12.2	25.5	37.5	2.6	8.9	14.8	22.9	1.5	36.7
Vetch and oats (1-1),	3	15	7.4	12.8	26.7	35.8	2.3	8.3	13.1	21.1	1.4	31.4
Wheat and vetch,	4	15	6.8	14.5	27.2	34.4	2.1	10.7	17.7	23.4	1.3	40.7
White daisy,	1	15	6.0	6.6	30.7	39.7	2.0	-	-	-	-	-

IV. VEGETABLES, FRUITS, ETC.

Apples,	2	78	0.7	1.0	1.5	18.3	0.5	-	-	-	-	-
Artichokes,	1	78	1.1	2.9	0.9	16.9	0.2	-	-	-	-	-
Beets, red,	7	88	1.1	1.5	0.7	8.6	0.1	-	-	-	-	-
Sugar beets,	13	86	0.9	1.6	0.9	10.5	0.1	1.5	0.9	10.5	0.1	10.5
Yellow fodder beets,	4	89	1.0	1.3	1.0	7.5	0.2	1.0	-	4.2	-	3.3
Cabbages,	1	90	0.8	2.6	0.9	5.5	0.2	-	-	-	-	-
Carrots,	5	89	0.9	1.0	1.1	7.8	0.2	-	-	-	-	-
Cranberries,	1	89	0.2	0.5	1.2	8.5	0.6	-	-	-	-	-
Mangolds,	5	88	1.2	1.4	0.8	8.5	0.1	1.0	0.3	7.7	-	6.9
Parsnips,	1	80	1.5	1.3	1.5	15.0	0.7	-	-	-	-	-
Potatoes,	54	80	0.8	2.1	0.5	16.5	0.1	1.0	-	14.8	-	16.9
Potatoes,	125	80	-	-	-	14.3 ²	-	-	-	-	-	-
Ruta-bagas,	3	89	1.1	1.2	1.3	7.2	0.2	1.0	1.0	6.8	0.2	7.6
Japanese radish,	1	93	0.7	0.5	0.7	5.0	0.1	-	-	-	-	-
Turnips,	5	90	0.9	1.5	1.2	6.6	0.2	1.4	1.2	6.3	0.2	7.7

V. CONCENTRATED FEEDS.

(a) Protein.

Alfalfa meal,	1	9	8.0	13.2	32.7	35.8	1.3	9.8	15.0	25.8	0.5 ³	31.2
Horse beans,	1	14	3.8	25.8	7.0	48.6	0.8	-	-	-	-	-
Red adzinki beans,	2	14	3.6	21.0	4.0	56.7	0.7	-	-	-	-	-
Saddle beans,	1	14	5.3	13.0	4.1	49.4	14.2	-	-	-	-	-
Soy bean,	5	14	5.0	31.2	4.7	28.4	16.7	28.4	-	23.0	15.5	91.7

¹ Digestion coefficients taken from the German.² Starch.³ Same coefficients used as for alfalfa hay.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — Continued.
 [Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therms.).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
V. CONCENTRATED FEEDS — Con.												
(a) <i>Protein</i> — Con.												
Soy bean (medium green),	3	14	4.6	35.3	4.0	24.3	17.8	32.1	-	19.7	16.6	94.7
Soy bean cake,	1	8	5.4	41.6	4.8	31.6	8.6	-	-	-	-	-
Blood meal, Armour's edible,	3	11	3.1	84.3	-	1.2	0.4	70.8	-	-	-	-
Brewers' dried grains,	19	10	3.6	24.0	13.4	42.8	6.2	19.4	6.6	24.4	5.5	56.4
Brewers' wet grains,	1	77	0.7	6.7	3.8	9.8	2.0	5.3	2.0	5.7	1.8	15.2
Buckwheat feed,	2	10	3.2	15.9	22.0	44.8	4.1	-	-	-	-	-
Buckwheat middlings,	3	10	4.7	26.7	6.8	44.6	7.2	22.7	1.1	37.0	6.4	76.8
Calf meal (Schumachers),	2	9	2.2	18.7	2.0	60.2	7.9	-	-	-	-	-
Cocunut meal,	3	9	4.7	20.4	11.0	40.6	4.3	-	-	-	-	-
Cottonseed meal,	404	7	6.7	44.6	6.5	25.2	10.0	37.5	2.3	19.7	9.4	80.8
Cottonseed meal (low grade),	33	8	4.6	24.9	18.0	37.0	7.5	18.9	7.0	27.0	7.1	62.2
Dairy feed, Union Grains,	1	7	6.2	25.2	9.9	44.1	7.6	19.2	9.2	37.9	7.4	-
Dairy feed Buffalo Creamery,	1	9	4.3	19.9	12.4	50.2	4.2	16.1	6.8	35.6	3.7	-
Dairy feed, Unicorn,	1	8	3.3	27.3	9.0	46.1	6.3	21.3	6.5	41.0	6.0	-
Distillers' dried grains, largely from corn,	81	8	1.7	31.7	12.3	34.1	12.2	23.1	11.7	27.6	11.6	80.2

Gluten feed,	278	8.5	1.9	25.9	7.2	53.3	3.2	22.0	6.3	48.0	2.6	77.8
Gluten flour, wheat,	1	5.5	0.4	84.8	0.2	8.1	1.0	-	-	-	-	-
Gluten meal, wheat,	2	8.0	0.9	39.8	0.8	48.9	1.6	-	-	-	-	-
Gluten meal,	139	9.5	1.0	36.0	2.1	49.1	2.3	31.7	-	43.2	2.1	74.9
Germ oil meal,	13	9.0	2.7	22.7	9.3	45.9	10.4	15.7	-	37.2	10.1	79.4
Flax screenings,	2	8.0	6.0	16.8	13.7	40.9	14.6	-	-	-	-	-
Flaxseed meal,	2	7.0	3.5	23.5	5.5	23.3	37.2	-	-	-	-	-
Linseed meal (new process),	58	9.0	5.6	37.4	8.9	36.4	2.7	31.5	6.6	29.1	2.4	72.7
Linseed meal (old process),	138	8.5	5.2	34.3	8.5	36.4	7.1	30.5	4.8	28.4	6.3	80.3
Malt sprouts,	32	11.0	5.9	26.4	12.3	43.1	1.3	20.1	12.2	36.6	1.1	56.4
Bibby's dairy cake,	4	10.0	7.7	19.7	8.6	44.9	9.1	13.0	4.0	36.4	8.4	-
Holstein sugar feed,	1	8.0	6.7	12.6	10.0	60.0	2.7	8.3	4.4	48.6	2.4	-
Sucrene dairy feed,	9	9.0	6.4	16.9	11.4	52.0	3.3	10.3	8.2	38.0	3.1	-
Oat middlings, fine,	4	9.0	2.3	15.8	2.4	64.3	6.2	12.8	1.2	61.7	5.8	92.2
Pea meal,	1	10.0	2.6	18.9	17.5	49.4	1.6	15.7	4.6	46.4	0.9	70.4
Peanut bran,	2	5.0	4.8	19.2	9.1	33.6	28.3	-	-	-	-	-
Peanut germ,	2	3.0	3.4	28.5	3.3	18.4	43.4	-	-	-	-	-
Peanut meal,	1	8.0	4.0	49.0	3.5	24.7	10.8	44.6	0.8	22.7	9.6	94.1
Rye feed,	20	11.0	3.3	14.8	3.8	64.4	2.7	11.8	-	56.7	2.4	78.2
Sun flower seed cake,	1	10.0	4.2	34.8	10.9	21.8	18.3	-	-	-	-	-
Wheat middlings (flour),	140	10.0	3.2	18.8	3.3	59.9	4.8	16.5	1.2	52.7	4.1	83.8
Wheat middlings (standard),	371	10.0	4.3	17.8	7.0	55.9	5.0	13.8	2.1	43.5	4.4	57.6
Wheat mixed feed, bran and middlings,	859	10.0	5.3	16.9	8.1	55.2	4.5	13.2	5.0	42.5	3.9	-

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — Continued.

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therms.).	
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.		
V. CONCENTRATED FEEDS — Con.													
(a) Protein — Con.													
Wheat mixed feed, adulterated,	7	10.0	4.3	12.3	15.5	54.6	3.3	7.7	4.3	38.8	3.0	-	
Wheat bran,	452	10.0	6.2	16.1	10.0	53.3	4.4	12.4	3.9	37.8	2.8	49.0	
Wheat bran (spring),	4	10.0	5.8	16.1	10.5	52.6	5.0	12.2	4.6	38.9	3.2	-	
Wheat bran (winter),	3	10.0	6.2	15.3	8.6	57.0	2.9	11.8	2.3	37.1	1.9	-	
Wheat screenings,	1	8.0	4.9	15.6	9.1	54.7	7.7	11.7	5.9	46.5	7.2	-	
(b) Starchy.													
Bakery refuse,	1	12.0	10.1	8.0	0.3	63.0	5.6	-	-	-	-	-	
Barley,	7	12.0	2.5	11.4	5.7	66.6	1.8	10.0	4.0	61.9	1.5	82.3	
Dried beet pulp,	2	10.0	3.3	9.1	18.6	58.3	0.7	-	-	-	-	-	
Dried molasses beet pulp,	4	8.0	5.8	9.9	14.1	61.7	0.5	6.3	11.8	56.1	-	72.1	
Broom corn seed,	3	12.0	2.7	10.4	7.4	64.2	3.3	-	-	-	-	-	
Buckwheat,	1	12.0	1.9	9.9	10.3	63.5	2.4	-	-	-	-	-	
Cassava starch refuse,	1	12.0	1.6	0.8	6.1	78.8	0.7	-	-	-	-	-	
Cocoa dust,	1	7.0	6.3	14.4	5.5	42.7	24.1	-	-	-	-	-	
Cocoa shells,	1	5.0	8.4	18.0	15.9	50.9	1.8	-	-	-	-	-	

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Concluded.*
 [Figures equal percentages or pounds in 100]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.				Net Energy Values (Therms.).	
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.		
CONCENTRATED FEEDS— <i>Con.</i>													
<i>(b) Starchy — Con.</i>													
Oat kernels,	10	11.0	3.0	12.5	8.5	60.4	4.6	10.7	2.6	47.7	3.8 ¹	69.7	
Oats, ground,	10	12.0	3.0	12.3	8.4	59.7	4.6	10.1	1.2	51.3	3.7 ¹	71.2	
Oat feed,	122	7.0	5.5	7.9	21.8	55.0	2.8	5.1	7.0	23.1	2.5	40.9	
Oat feed (low grade),	17	7.0	5.5	5.1	26.4	54.4	1.6	3.2	8.4	18.0	1.5	33.2	
Oat feed, Canada,	2	7.0	5.4	13.2	24.8	44.7	4.9	9.1	8.2	22.8	4.3	49.5	
Pea bran,	2	11.0	2.7	10.0	39.7	35.6	1.0	-	-	-	-	-	
Peanut shells, ground, ²	5	9.4	2.4	7.4	60.6	16.9	3.3	-	-	-	-	-	
Rice, cleaned,	1	11.0	0.3	8.5	0.1	79.8	0.3	-	-	-	-	-	
Rice, bran,	2	11.0	12.7	6.8	20.6	42.8	6.1	4.3	6.0	33.4	5.4	-	
Rice meal,	2	11.0	8.2	11.8	5.3	50.8	12.9	7.3	-	46.7	11.7	87.7	
Rye middlings,	1	11.0	3.6	11.7	3.3	65.4	5.0	-	-	-	-	-	
Speltz,	1	8.0	3.9	11.5	11.1	62.9	2.2	9.2	6.7	56.0	1.9	-	
Starch refuse,	2	12.0	1.8	4.8	3.8	76.3	1.3	-	-	-	-	-	
Red wheat kernels,	1	12.0	1.7	8.8	2.6	72.4	2.5	5.9	1.0	66.6	2.0	78.9	
White winter wheat kernels,	1	12.0	1.7	11.5	2.1	70.8	1.9	9.4	1.6	65.8	1.2	80.3	

Wheat kernels,	13	12.0	1.8	12.0	2.6	69.7	1.9	9.0	1.5	64.8	1.4	78.9
Wheat flour,	2	12.0	0.4	9.9	0.1	76.8	0.8	-	-	-	-	-
<i>(c) Poultry.</i>												
Green cut bone,	2	27.0	19.2	18.6	-	5.8	29.4	-	-	-	-	-
Raw ground bone,	1	8.0	64.4	23.9	-	3.4	0.3	-	-	-	-	-
Out clover,	2	10.0	6.8	17.9	20.5	41.8	3.0	-	-	-	-	-
Meat and bone meal,	38	6.0	37.3	39.6	-	6.3	10.8	-	-	-	-	-
Meat scrap,	12	9.0	18.4	50.6	-	4.2	17.8	-	-	-	-	-
Rava meat meal,	1	10.0	1.7	83.2	-	-	5.1	-	-	-	-	-
Mutton scrap,	1	7.0	33.1	39.9	-	5.3	14.7	-	-	-	-	-
Fish glue waste,	1	14.0	34.9	39.1	-	4.1	7.9	-	-	-	-	-
Milk albumen,	1	11.0	31.4	42.4	-	14.4	0.8	-	-	-	-	-
Granulated milk,	1	10.0	26.5	35.9	-	18.1	9.6	-	-	-	-	-

¹ Coefficients obtained from digestion experiments with horses.² Valueless for feeding.

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES.¹

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. GREEN FODDERS.					
<i>(a) Meadow Grasses and Millets.</i>					
Orchard grass,	4	70	0.43	0.56	0.13
Millet,	1	80	0.29	0.43	0.11
Barnyard millet,	3	80	0.30	0.67	0.10
Hungarian grass,	1	80	0.30	0.42	0.12
Japanese millet,	3	80	0.33	0.22	0.10
<i>(b) Cereal Fodders.</i>					
Corn fodder,	22	80	0.39	0.30	0.13
Oats,	3	75	0.72	0.56	0.19
Rye,	2	75	0.27	0.57	0.11
<i>(c) Legumes.</i>					
Alfalfa,	4	80	0.44	0.31	0.11
Horse bean,	1	85	0.41	0.21	0.05
Soy bean (early white),	1	80	0.57	0.55	0.13
Soy bean (medium green), average,	14	80	0.64	0.53	0.14
Soy bean (medium green), in bud,	1	80	0.66	0.58	0.15
Soy bean (medium green), in blossom,	5	80	0.64	0.60	0.13
Soy bean (medium green) in pod,	7	78	0.72	0.52	0.17
Soy bean (medium black),	1	80	0.70	0.50	0.16
Soy bean (late),	1	80	0.60	0.68	0.14
Alsike clover,	6	80	0.53	0.50	0.15
Mammoth red clover,	3	80	0.50	0.27 ²	0.12
Medium red clover, average,	10	80	0.52	0.57	0.11
Medium red clover, in bud,	2	80	0.58	0.71	0.13
Medium red clover, in blossom,	3	79	0.51	0.58	0.12
Medium red clover, seeding,	2	75	0.61	0.65	0.13
Sweet clover,	1	80	0.43	0.40	0.12
White lupine,	1	85	0.45	0.26	0.05
Yellow lupine,	1	85	0.40	0.44	0.09
Canada field peas, average,	6	85	0.50	3.08	0.12

¹ Many of these analyses were made in earlier years by the Massachusetts State Experiment Station. The percentages of the several ingredients will vary considerably depending upon the fertility of the soil, and especially upon the stage of growth of the plant. In the majority of cases the number of samples analyzed is too few to give a fair average. The figures, therefore, must be regarded as close approximations rather than as representing absolutely the exact fertilizing ingredients of the different materials. (J. B. L.)

² Evidently below normal.

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. GREEN FODDERS — <i>Con.</i>					
<i>(c) Legumes — Con.</i>					
Canada field peas, in bud,	2	85	0.50	0.44	0.11
Canada field peas, in blossom,	2	87	0.45	0.32	0.11
Canada field peas, in pod,	2	84	0.52	0.37	0.13
Cow pea, average,	9	85	0.45	0.47	0.12
Black cow peas,	4	85	0.40	0.47	0.12
Whip-poor-will cow peas,	5	85	0.49	0.47	0.12
Flat pea,	1	85	0.75	0.32	0.10
Small pea,	1	85	0.40	0.31	0.09
Sainfoin,	1	75	0.68	0.57	0.20
Serradella,	2	85	0.36	0.37	0.12
Sulla,	2	75	0.68	0.58	0.12
Spring vetch,	1	85	0.36	0.45	0.10
Hairy or sand vetch, average,	5	85	0.55	0.51	0.13
Hairy or sand vetch, in bud,	2	86	0.52	0.54	0.12
Hairy or sand vetch, in blossom,	3	82	0.65	0.57	0.16
Kidney vetch,	1	85	0.44	0.28	0.08
Average for legumes,	-	-	0.53	0.44	0.12
<i>(d) Mixed and Miscellaneous.</i>					
Vetch and oats,	4	80	0.30 ¹	0.30	0.14
Apple pomace,	2	83	0.21	0.12	0.02
Carrot tops,	1	80	0.69	1.08	0.13
Prickley comfrey,	1	87	0.37	0.76	0.12
Common buckwheat,	1	85	0.44	0.54	0.09
Japanese buckwheat,	1	85	0.26	0.53	0.14
Silver-hull buckwheat,	1	85	0.29	0.39	0.14
Summer rape,	1	85	0.34	0.78	0.10
Sorghum,	8	80	0.26	0.29	0.11
Teosinte,	1	70	0.47	1.18	0.90
II. SILAGE.					
Corn,	7	80	0.42	0.39	0.13
Corn and soy bean,	1	76	0.65	0.36	0.35 ²
Millet,	3	74	0.26	0.62	0.14
Millet and soy bean,	5	79	0.42	0.44	0.11

¹ Too low; 0.43 nearer correct.² Evidently too high.

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
III. HAY AND DRY COARSE FODDERS.					
(a) <i>Meadow Grasses and Millets.</i>					
Barnyard millet,	3	14	1.29	2.88	0.43
Hungarian grass,	1	14	1.29	1.79	0.52
Italian rye grass,	4	14	1.12	1.19	0.53
Kentucky blue grass,	2	14	1.20	1.54	0.39
Meadow fescue,	6	14	0.93	1.98	0.37
Orchard grass,	4	14	1.23	1.60	0.38
Perennial rye grass,	2	14	1.16	1.47	0.53
Red-top,	4	14	1.07	0.95	0.33
Timothy,	3	14	1.20	1.42	0.33
English hay (mixed grasses),	13	14	1.34	1.61	0.32
Rowen,	13	14	1.72	1.58	0.48
Branch grass,	1	16	1.06	0.87	0.19
Fox grass,	1	16	1.18	0.95	0.18
Salt hay (variety uncertain),	1	16	1.05	0.64	0.23
(b) <i>Cereal Fodders.</i>					
Corn stover, from field,	17	40	0.69	0.92	0.20
Corn stover, very dry,	17	20	0.92	1.22	0.26
Oats,	3	15	2.45 ¹	1.90	0.65
(c) <i>Legumes.</i>					
Alsike clover,	6	15	2.26	2.10	0.63
Mammoth red clover,	3	15	2.14	1.16 ²	0.52
Medium red clover,	10	15	2.21	2.42	0.47
(d) <i>Straw.</i>					
Barley,	2	15	0.95	2.03	0.19
Soy bean,	1	15	0.69	1.04	0.25
Millet,	1	15	0.68	1.73	0.18
(e) <i>Mixed and Miscellaneous.</i>					
Vetch and oats,	4	15	1.29 ³	1.27	0.60
Broom corn waste (stalks),	1	10	0.87	1.87	0.47
Palmetto root,	1	12	0.54	1.37	0.16
Spanish moss,	1	15	0.61	0.56	0.07
White daisy,	1	15	0.26	1.18	0.41

¹ Too high; 1.90 nearer correct.² Evidently below normal.³ Too low; 1.80 nearer correct.

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
IV. VEGETABLES, FRUITS, ETC.					
Apples,	2	78	0.12	0.17	0.01
Artichokes,	1	78	0.46	0.48	0.17
Beets, red,	8	88	0.24	0.44	0.09
Sugar beets,	4	86	0.24	0.52	0.11
Yellow fodder beets,	1	89	0.23	0.56	0.11
Mangolds,	3	88	0.15	0.34	0.14
Carrots,	3	89	0.16	0.46	0.09
Cranberries,	1	89	0.08	0.10	0.03
Parsnips,	1	80	0.22	0.62	0.19
Potatoes,	5	80	0.29	0.51	0.08
Japanese radish,	1	93	0.08	0.40	0.05
Turnips,	4	90	0.17	0.38	0.12
Ruta-bagas,	3	89	0.19	0.49	0.12
V. CONCENTRATED FEEDS.					
(a) Protein.					
Red adzinki bean,	1	14	3.27	1.55	0.95
White adzinki bean,	1	14	3.45	1.53	1.00
Saddle bean,	1	14	2.08	2.09	1.49
Soy bean,	3	14	5.61	2.12	1.82
Blood meal (Armour's),	1	11	13.55	0.18	0.26
Brewers' dried grains,	2	8	3.68	0.86	1.06
Cottonseed meal,	167	7	7.08	2.05	2.90
Distillers' dried grains,	20	8	4.50	0.31	0.61
Gluten feed,	106	8.5	4.13	0.40	0.77
Gluten meal,	46	9.5	5.87	0.21	0.55
Linseed meal (new process),	21	9	5.97	1.42	1.79
Linseed meal (old process),	56	8.5	5.35	1.30	1.66
Malt sprouts,	12	11	4.32	2.00	1.56
Bibby's dairy cake,	1	10	2.94	1.67	2.07
Sucrene feed,	1	10	2.62	2.08	0.55
Pea meal,	1	10	3.04	0.98	1.81
Peanut meal,	1	8	7.84	1.54	1.27
Proteina,	1	8	3.04	0.58	1.02

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V. CONCENTRATED FEEDS—<i>Con.</i>					
<i>(a) Protein—Con.</i>					
Rye feed,	11	11	2.36	1.08	1.60
Wheat middlings (flour),	44	10	3.06	1.01	1.65
Wheat middlings (standard),	103	10	2.88	1.28	2.06
Wheat mixed feed,	282	10	2.72	1.44	2.57
Wheat bran,	116	10	2.59	1.45	2.79
<i>(b) Starchy.</i>					
Ground barley,	1	13	1.56	0.34	0.66
Buckwheat hulls,	1	12	0.49	0.52	0.07
Cocoa dust,	1	7	2.30	0.63	1.34
Corn cobs,	8	8	0.52	0.63	0.06
Corn and cob meal,	29	11	1.38	0.46	0.56
Corn kernels,	13	11	1.82	0.40	0.70
Corn meal,	3	14	1.92	0.34	0.71
Corn and oat feed (Victor),	2	10	1.38	0.61	0.59
Corn, oat and barley feed (Schumachers),	1	8	1.80	0.63	0.83
Cotton hulls,	3	11	0.75	1.08	0.18
Hominy meal,	125	11	1.65	0.76	1.27
Common millet seed,	2	12	2.00	0.45	0.95
Japanese millet seed,	1	12	1.58	0.35	0.63
Molasses (Porto Rico),	1	24	0.51	3.68	0.12
Dried molasses beet pulp,	1	8	1.60	1.47	0.16
Oat kernels,	1	11	2.05	—	—
Oat feed,	14	7	1.26	0.75	0.48
Oat feed (low grade),	15	7	0.88	0.70	0.35
Peanut feed,	2	10	1.46	0.79	0.23
Peanut husks,	1	13	0.80	0.48	0.13
Louisiana rice bran,	1	11	1.42	0.83	1.70
Rye middlings,	1	11	1.87	0.82	1.28
Damaged wheat,	1	13	2.26	0.51	0.83
Wheat flour,	2	12	2.02	0.36	0.35
<i>(c) Poultry.</i>					
American poultry food,	1	8	2.22	0.52	0.98
Meat and bone meal,	10	6	5.92	—	14.68
Meat scraps,	4	9	7.63	—	8.11

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Concluded.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
VI. DAIRY PRODUCTS.					
Whole milk,	297	86.4	0.57	0.19 ¹	0.16
Human milk,	3	88.1	0.24	—	—
Skim milk,	22	90.3	0.59	0.18 ²	0.20
Butter milk,	1	91.1	0.51	0.05	0.04
Whey,	1	93.7	0.10	0.07	0.17
Butter,	117	12.5	0.19	—	—

¹ From Farrington and Woll.² From Woll's Handbook.

TABLE III. — ANALYSES OF DAIRY PRODUCTS.

[Per Cent.]

NAME.	Number of Analyses.	Solids.			Fat.			Proteids (N. \times 6.25).	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	6,399 ¹	19.55	10.02	13.55	10.70	1.50	4.49	3.52 ²	—	0.73 ³
Human milk,	3	13.59	10.50	11.87	3.77	1.66	2.52	1.48	—	0.24
Colostrum,	2	24.75	21.25	23.00	3.00	3.00	3.00	2.84 ⁴	—	1.00
Skim milk (largely from Cooley process),	359	10.48	7.68	9.20	1.80	0.05	0.32	—	—	—
Buttermilk,	31	9.86	6.83	8.33	0.38	0.11	0.27	—	—	—
Cream (from Cooley process),	203	32.78	18.12	26.10	25.00	10.53	17.60	—	—	—
Butter (salted),	189	94.84	82.55	86.95	89.33	75.94	82.65	1.11 ⁵	3.21	—
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	0.76	—	—

¹ Largely station herd, Jersey blood predominating.² Average of 961 samples.³ Average of 388 samples.⁴ Nitrogen.⁵ Curd and natural ash.

TABLE IV.—COEFFICIENTS OF DIGESTIBILITY OF
AMERICAN FODDER ARTICLES. EXPERIMENTS
MADE IN THE UNITED STATES.¹

J. B. LINDSEY AND P. H. SMITH.

EXPERIMENTS WITH RUMINANTS.

EXPERIMENTS WITH SWINE.

EXPERIMENTS WITH HORSES.

EXPERIMENTS WITH POULTRY.

EXPERIMENTS WITH CALVES.

Complete through Aug. 1, 1910.

EXPLANATION OF TABLE IV.

The first compilation of all digestion coefficients resulting from experiments made in the United States was made and published by J. B. Lindsey in 1896.² Jordon and Hall also published very complete data in 1900.³ Since then the writer and his co-workers have revised and published similar tables in 1902⁴ and 1906.⁵ The present publication is intended to be complete to December, 1910.

By *coefficient of digestibility* is meant the percentage of the ingredients which the animal can actually digest. Thus, of the 6.3 pounds of total protein in 100 pounds of Timothy hay, experiments have shown that 48 per cent., or 3 pounds, are digestible. The figure 48 is the digestion coefficient. The average coefficients determined have been applied to the average fodder analyses in Table I., and have enabled us to calculate the average amount of each fodder constituent digestible.

¹ Being a portion of the report of the Department of Plant and Animal Chemistry.

² Ninth report of the Hatch Experiment Station, pp. 157-170.

³ Bulletin 77, United States Department of Agriculture, Office of Experiment Stations.

⁴ Fourteenth report of the Hatch Experiment Station, pp. 195-216.

⁵ Eighteenth report of the Hatch Experiment Station, pp. 224-248.

EXPERIMENTS WITH RUMINANTS.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen- free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. GREEN FODDERS.									
(a) <i>Meadow Grasses and Millets.</i>									
Grass, native blue, Nevada (<i>Poa Sandbergii</i>),	1	2 {	52-53 53	-	20-25 23	64-64 64	44-45 45	60-61 60	48-51 50
Grass, meadow, young,	1	1	69	-	-	65	74	72	55
Grass, meadow, young, dried,	1	1	71	-	-	71	77	73	60
Grass, timothy,	1	3 {	63-65 64	-	31-33 32	48-48 48	54-58 56	65-67 66	52-54 52
Grass, timothy, rowen,	1	2 {	-	65-67 66	-	72-72 72	60-68 64	67-68 68	51-55 52
Grass, Western brome (<i>Bromus marginatus</i>),	1	2 {	60-60 60	-	42-42 42	68-68 68	53-53 53	67-67 67	15-16 16
Barnyard millet in blossom (Massachusetts) (<i>Panicum crus- galli</i>).	3	6 {	67-76 70	-	45-67 56	58-70 65	71-77 73	65-77 71	54-67 58
Japanese millet, bloom to early seed (Storrs),	2	3 {	-	62-66 64	52-53 55	45-57 50	59-63 62	64-68 67	60-72 68
Hungarian grass, early to late bloom,	3	8 {	61-71 66	61-74 68	-	59-72 63	65-76 70	64-71 67	48-85 62
(b) <i>Cereal Fodders.</i>									
Barley fodder, bloom,	2	4 {	-	62-71 67	-	69-73 72	49-66 61	69-76 71	56-63 60
Barley fodder, seeds forming,	2	2 {	-	66-71 68	40-44 42	67-71 69	47-65 56	- 74	48-50 49
Corn fodder, dent, immature,	5	14 {	64-74 68	-	42-43 42	56-80 66	50-76 65	64-79 71	37-83 86

Corn fodder, dent, milk, average,	7	17	70	-	39 ¹	62	64	77	76
Corn fodder, dent, mature, average,	12	23	69	72 ²	34	54	59	75	75
Corn fodder, dent, mature, B. & W., coarse,	1	2 {	51-54 52	-	-	20-28 24	46-47 46	57-61 59	74-82 78
Corn fodder, dent, brewers, milk,	1	2 {	71-73 72	-	44-49 46	68-69 69	67-71 69	76-77 77	67-70 68
Corn fodder, dent, early Mastodon, milk,	1	2 {	72-72 72	-	33-38 36	56-58 57	60-60 60	79-79 79	80-81 81
Corn fodder, Eureka silage, ears just forming,	1	3 {	64-69 67	-	42-43 42	67-68 67	56-61 60	70-74 72	65-67 66
Corn fodder, dent, Leaming, milk,	1	2 {	69-71 70	-	34-40 36	60-60 60	60-63 61	76-77 77	75-77 76
Corn fodder, dent, Pride of the North, mature,	2	4 {	69-81 74	-	29-40 35	59-68 63	58-74 66	76-86 81	74-78 80
Corn fodder, dent, Rustler's white, mature,	1	2 {	69-70 70	-	25-30 28	40-45 43	57-61 59	77-79 78	75-78 76
Corn fodder, dent, Wing's improved white cap, milk,	1	2 {	70-71 70	-	38-40 39	62-64 63	62-68 65	76-76 76	69-71 70
Corn fodder, flint, Sanford, mature,	2	4 {	63-73 69	67-75 71	14-50 34	46-57 52	67-80 75	67-75 71	53-74 66
Corn fodder, sweet, milk stage,	1	2 {	77-78 77	-	-	77-78 77	74-76 75	80-81 81	73-74 74
Corn fodder, sweet, roasting stage,	9	12 {	-	67-79 72	22-61 48	52-69 62	54-72 60	73-82 77	62-82 74
Oat fodder, bloom to early seeding,	3	5 {	-	56-65 62	49-68 60	68-76 73	43-63 55	60-67 62	67-72 69
Rye fodder, heading,	1	2 {	73-74 74	-	-	79-80 79	80-80 80	70-71 71	74-74 74
Sorghum fodder, blossom,	1	2 {	73-73 73	-	-	51-56 53	74-75 75	78-78 78	81-82 81

¹ Average eight trials.² Average seventeen trials.

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. GREEN FODDERS — Con.									
(b) <i>Cereal Fodders</i> — Con.									
Sorghum fodder, Early Amber, past blossom,	2	4 {	61-69 65	-	40-43 42	38-51 44	42-72 55	70-74 73	60-67 64
Sorghum fodder, average,	3	6	68	-	42	47	62	75	70
(c) <i>Legumes</i> .									
Alfalfa, fodder,	1	2 {	61-61 61	-	40-40 40	73-75 74	42-43 43	71-72 72	38-39 39
Soy beans, variety uncertain, before bloom,	1	2 {	-	64-67 66	-	77-80 79	45-55 50	71-73 72	50-58 54
Soy beans, variety uncertain, seeding,	1	2 {	-	61-63 62	-	68-71 69	38-43 41	72-75 73	49-59 54
Soy beans, medium green, full blossom,	1	2 {	-	62-63 63	22-28 25	76-78 77	45-49 47	69-73 71	46-54 50
Soy beans, medium green, seeding,	4	12 {	62-69 65	65-69 67	16-45 28	74-84 78	31-53 45	71-81 77	31-69 55
Clover, crimson, late blossom,	1	3 {	-	68-70 69	-	77-77 77	54-68 56	74-75 74	63-69 66
Clover, red, late blossom,	1	2 {	65-67 66	-	-	66-68 67	52-53 53	76-79 78	63-66 65
Clover, rowen, late blossom,	1	2 {	-	60-62 61	-	61-62 62	51-54 52	64-68 65	60-61 61
Clover, average two samples,	2	4 {	65-67 66	60-62 61	-	61-68 65	51-54 53	64-79 72	60-66 63
Cow peas, ready for soiling,	2	4 {	66-77 68	72-76 74	19-28 23	73-77 76	57-62 60	76-84 81	56-62 59

Little Lupine (<i>Lupinus Sp.</i>),	1	2 {	62-74 68	-	65-69 67	73-77 75	46-65 56	67-84 76	42-72 57
Canada field peas, before bloom,	1	2 {	68	71-72 71	-	81-83 82	62-62 62	71-71 71	50-55 52
Canada field peas, bloom to seeding,	2	6 {	60-67 64	-	26-45 37	79-83 81	40-52 45	72-80 76	45-64 55
Spring vetch (<i>Vicia sativa</i>),	1	2 {	62-62 62	-	17	71-72 72	42-46 44	75-77 76	57-60 59
Winter or hairy vetch (<i>Vicia villosa</i>), bloom,	4	14 {	66-78 71	-	29-55 42	79-88 83	52-73 63	68-84 77	68-82 71
(d) Mixed and Miscellaneous.									
Apple pomace,	2	6 {	66-80 72	-	24-63 49	-	36-85 65	80-90 85	39-52 46
Balsam root or big sunflower (<i>Balsamorhiza sagittata</i>),	1	2 {	66-66 66	-	34-42 38	76-79 78	57-61 59	74-76 75	74-75 74
Barley and peas, bloom,	3	4 {	-	55-71 65	52-55 54	73-81 75	38-61 52	56-76 68	54-65 59
Bitter brush (<i>Kunzia tridentata</i>),	1	2 {	75-79 77	-	48-69 59	79-85 82	56-83 70	86-87 87	70-73 71
Wild carrot (<i>Septolaenia multifida</i>),	1	2 {	68-69 69	-	52-54 53	70-72 71	43-52 47	82-84 83	81-82 82
Wild dandelion (<i>Crepis intermedia</i>),	1	2 {	62-63 63	-	58-60 59	61-65 63	34-37 36	77-78 78	31-35 33
Thousand headed kale (<i>Brassica oleracea</i>),	2	4 {	66-71 68	-	37-45 39	78-83 81	55-64 59	74-77 76	61-72 66
Oats and spring vetch, bloom,	1	3 {	65-69 67	-	49-55 53	73-76 75	65-72 68	66-70 68	42-52 47
Oats and peas, bloom,	2	5 {	69-72 70	67-69 68	45-52 49	68-82 74	54-70 64	66-77 72	51-74 64
Oats and peas, partly seeded,	3	5 {	-	58-70 62	36-63 47	68-83 74	48-67 55	56-67 63	55-74 64

EXPERIMENTS WITH RUMINANTS — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. GREEN FODDERS — Con.									
(d) Mixed and Miscellaneous — Con.									
Prickly pear (<i>Opuntia lindheimeri</i>),	1	2 {	65—67 66	71—77 74	34—37 36	57—59 58	41—41 41	82—83 83	67—68 68
Prickly pear (<i>Opuntia lewis?</i>),	1	2 {	63—65 64	70—73 71	33—38 36	39—42 41	51—56 54	78—80 79	69—69 69
Prickly pear (<i>Opuntia engelmannii cycloides</i>),	2	4 {	57—70 65	63—75 71	39—44 42	— —	30—45 39	77—83 81	74—88 83
Mountain Indian Pink or Painted Cup (<i>Castilleja miniata</i> var.),	1	2 {	66—68 67	— —	40—47 47	63—66 65	48—50 49	79—81 80	75—78 77
Indian potato (<i>Atenia Gairdnerii</i>),	1	2 {	66—67 67	— —	50—50 50	54—59 57	73—75 74	64—66 65	76—78 77
Dwarf Essex rape, first growth,	1	2 {	88—88 88	— —	76—77 76	90—91 90	90—90 90	94—94 94	54—55 54
Dwarf Essex rape, second growth,	1	2 {	81 —	— —	47—51 49	86—89 87	84—84 84	90—91 90	42—44 43
Dwarf Essex rape, average,	2	4	85	—	63	89	87	92	48
Common sunflower, Nevada (<i>Wyehtia mollis</i>),	1	2 {	60—62 61	— —	53—53 53	69—70 69	54—55 54	59—63 61	62—64 63
Winter wheat and hairy vetch,	2	5 {	68—71 69	— —	40—46 44	69—78 75	66—71 68	71—76 73	54—61 57
II. SILAGE.									
Soy bean silage, goats,	1	2 {	52—66 59	— —	— —	71—80 76	47—62 55	46—53 52	66—77 72
Soy bean silage, steers,	1	2 {	50—50 50	— —	— —	54—56 55	42—44 43	61—61 61	47—52 49

Soy bean silage, mammoth yellow, bloom,	1	3 {	52-65 58	63-73 67	-	57-69 61	51-67 59	74-80 76	48-60 52
Soy bean silage, average,	3	7	56	67	-	66	53	65	57
Soy bean and barnyard millet silage,	1	4 {	54-65 59	-	-	55-62 57	61-73 69	54-63 59	69-75 72
Soy bean and corn silage (9 pints beans, 14 pints corn),	4	8 {	62-73 69	71-75 72	39-48 42	54-68 63	51-73 63	73-81 78	67-91 83
Clover silage,	2	5 {	32-52 44	36-54 45	26-51 36	22-40 35	41-55 48	31-56 45	36-60 45
Corn silage, dent, immature, average all trials,	7	17 {	59-68 64	60-68 64	31-35 33	42-65 53	54-78 68	60-70 66	61-85 71
Corn silage, dent, mature, average all trials,	10	27 {	57-76 66	60-77 70	24-54 38	21-69 51	45-80 65	63-83 71	65-90 82
Corn silage, dent, Leaming, immature,	2	4 {	59-66 62	60-68 64	31-35 33	46-51 49	54-71 63	62-66 65	61-77 72
Corn silage, dent, Leaming, mature,	1	2 {	68-72 70	-	46-54 50	59-69 64	68-74 71	71-74 73	83-86 85
Corn silage, dent, Pride of the North, mature,	1	2 {	72-76 74	-	24-28 26	-	72-73 73	81-83 82	72-82 77
Corn silage, dent, Virginia, mature,	1	4 {	57-74 64	60-75 66	-	21-55 39	51-69 58	66-79 72	65-84 77
Corn silage, Sanford, ears glazing,	1	2 {	74-76 75	76-77 77	47-48 48	54-54 54	77-78 78	78-80 79	76-78 77
Corn silage, dent, average all trials,	17	48	64	70 ¹	38	50	65	69	77
Corn silage, flint, mature, small varieties,	4	11 {	68-78 75	66-80 77	-	48-73 65	75-79 77	71-83 79	- 82
Corn silage, flint, large white, partly eared,	1	2 {	69-70 70	72-73 72	31-37 34	56-56 56	72-72 72	75-76 76	72-74 73
Corn silage, fine crushed, steers,	1	2 {	60-68 64	-	-	32-44 38	72-78 75	60-70 65	75-77 76

¹ Average twenty-five trials.

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
II. SILAGE—Con.									
Corn silage, fine crushed, sheep,	1	2 {	51—56 54	—	—	21—22 21	59—68 64	53—57 55	67—69 68
Corn silage, mature, fed raw,	1	1	—	—	—	45	59	71	86
Corn silage, mature, cooked,	1	1	—	—	—	39	70	75	87
Corn silage, steamed,	1	2 {	73—74 73	75—76 76	46—50 48	53—57 55	75—76 76	75—77 76	90—90 90
Corn silage, variety unknown,	1	2 {	—	—	—	55—58 57	68—68 68	78—78 78	66—67 66
Corn silage, variety unknown, raw,	1	2 {	71—73 72	—	40—45 43	54—63 59	72—75 74	74—76 75	90—90 90
Corn silage, variety unknown, steamed,	1	2 {	60—62 61	—	5—13 9	5—6 5	62—64 63	70—72 71	79—80 79
Corn silage, sweet, mature,	1	2 {	67—70 68	68—72 70	—	53—55 54	68—74 71	71—73 72	82—85 83
Kafir corn silage, well matured,	1	3 {	54—56 55	56—59 57	—	22—23 28	57—59 57	59—62 62	47—54 50
Oat and pea silage,	1	2 {	63—68 65	63—70 67	52—53 52	74—75 75	58—65 61	64—70 67	73—77 75
Cow pea silage,	1	4 {	59—60 60	—	—	57—58 57	50—54 52	72—73 72	62—64 63
Sorghum silage, well matured,	1	3 {	51—60 57	53—62 59	—	6—13 9	51—63 55	59—67 64	53—60 56
Silage, mixture of corn, sunflower heads and horse beans, ¹	1	2 {	64—68 66	66—70 68	40—41 41	60—65 63	56—64 60	71—74 72	75—78 77

Silage, mixture of corn, sunflowers (whole plant) and horse beans.¹

Vetch silage, raw,

Vetch silage, steamed,

III. HAY AND DRY COARSE FODDERS.

(a) Meadow Grasses and Millets.

Kentucky blue grass (*Poa pratensis*),

Canada blue grass (*Poa compressa*), bloom,

Blue-joint, bloom,

Blue-joint, past bloom,

Bromus inermis hay,

Buffalo grass (*Bulbilia Dactyloides*),

Chess or cheat (*Bromus secalinus*),

Colorado upland hay (largely *Apropyrum tenerum*),

Cord grass (*Spartina Cynosuroides* L.),

Crab grass (*Eragrostis Neo Mexicana*), ripe,

Dakota lowland prairie hay,

Dakota upland prairie hay,

1	2 {	64-67 65	68-71 69	20-31 26	57-59 58	63-68 65	72-75 74	72-76 74
1	2 {	62-64 63	-	46-48 47	56-57 56	61-64 63	66-68 67	76-79 77
1	2 {	50-53 51	-	35-40 38	13-16 15	50-53 51	61-64 63	63-63 63
2	7 {	56 ² -	-	9-42 23	47-63 57	63-74 66	53-69 61	43-62 52
1	2 {	62-63 62	-	42-42 42	43-44 43	70-71 71	63-63 63	36-39 37
1	2 {	67-70 69	68-71 70	-	68-72 70	71-73 72	66-71 69	51-53 52
1	1	40	42	-	57	37	43	37
2	4 {	-	-	-	45-52 50	55-61 59	66-70 68	17-31 24
1	1	55	-	6	54	65	62	62
1	1	45	-	23	42	46	49	32
2	6 {	47-63 56	45-59 52	40-48 43	58-67 62	54-63 59	49-66 57	16-53 34
1	6 {	-	-	16-38 23	34-42 39	54-58 56	46-52 49	47-55 50
3	8 {	47-57 53	-	29-52 43	30-56 58	50-66 60	50-59 53	30-52 43
1	2 {	-	-	-	41-44 43	59-61 60	56-57 57	40-40 40
1	6 {	-	-	5-17 11	28-40 32	45-61 53	44-55 51	25-84 32

¹ Proportion of one acre corn, one-fourth acre sunflower heads and one-half acre horse beans.

² One trial.

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY AND DRY COARSE FODDERS — Con.									
(a) Meadow Grasses and Millets — Con.									
Meadow fescue (<i>Festuca elatior pratensis</i>), bloom,	1	2 {	60—61 61	—	— 46	51—53 52	— 67	58—60 59	53—54 54
Johnson grass (<i>Andropogon halepensis</i>),	2	3	57	—	—	40	68	57	38
Barnyard millet, well headed,	1	3 {	57—58 57	—	63—64 63	63—64 64	60—64 62	50—52 52	44—50 46
Barnyard millet, just heading out,	1	2 {	59—62 61	—	51—52 52	56—59 58	66—71 69	55—59 57	47—49 48
Cat-tail millet (<i>Pennisetum spicatum</i>),	1	2 {	61—64 62	—	—	61—65 63	65—68 67	58—60 59	45—48 46
Golden millet,	1	1	54	—	31	23	56	58	49
Hungarian,	1	2 {	64—66 65	66—67 66	—	—	67—68 68	67—67 67	— 64
Millet (<i>Chatochloa Italica</i>),	1	2 {	52—58 56	—	16—32 24	30—32 31	60—66 63	52—59 56	48—52 50
Mixed grasses, rich in protein (8 to 10 per cent.),	21	73 {	54—69 61	60—66 62 ¹	37—53 47	34—65 57	49—78 62	56—63 62	26—58 50
Mixed grasses, timothy predominating,	5	10 {	49—59 55	51—61 58	16—36 30	37—54 47	46—50 65	56—66 59	39—57 45
Meadow, swale or swamp hay,	1	2 {	38—40 39	—	—	31—37 34	30—36 33	— 46	— 44
Nevada native hay, second growth, mixed grasses,	1	2 {	75—77 76	—	62—63 63	71—72 71	77—79 78	76—79 77	78—80 79

Millets.

Nevada native hay, half clover,	1	2	{	65-67 66	-	44-44 44	51-53 52	66-67 66	70-72 71	61-62 62
Nevada native hay, largely Buckley's blue grass,	1	2	{	64-65 65	-	44-45 45	46-47 47	-66 66	68-69 69	68-71 70
Nevada native hay, largely timothy and tickle grass,	1	2	{	73-75 74	-	57-61 59	64-64 64	71-77 74	78-79 79	70-74 72
Nevada native hay, largely wire grass and brown top sedge,	1	2	{	64-67 66	-	50-52 51	48-49 49	75-77 76	58-64 61	70-71 71
Tall oat grass (<i>Arrhenatherum elatius</i>), late bloom,	1	2	{	54-57 55	-	39-43 41	-	53-57 55	56-59 58	54-58 56
Wild oat grass (<i>Danthonia spicata</i>),	2	3	{	60-68 64	61-69 65	-	49-68 58	65-71 68	62-69 65	36-63 50
Orchard grass, ten days after bloom,	1	1		54	56	-	59	58	54	54
Orchard grass, stage not given,	1	2	{	57-60 59	-	-	60-60 60	60-67 64	55-57 56	55-57 56
Orchard grass, average both samples,	2	3		56	56	-	60	61	55	55
Pasture grass,	1	3		73	73	52	73	76	74	67
Prairie grass (<i>Sporobolus Asper</i>),	1	1		56	-	25	18	61	61	57
Red top,	2	3	{	58-62 60	59-64 61	-	60-62 61	61-62 61	59-65 62	44-59 51
Rowen, mixed grasses,	3	12	{	-	63-68 65	-	-	62-72 66	60-69 65	44-51 47
Rowen, chiefly timothy,	1	4	{	-	62-67 64	-	66-69 68	62-73 66	60-65 63	48-51 49
Rowen, average all trials,	4	16		-	65	-	69	66	64	47

1 Average sixty trials.

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.		Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY AND DRY COARSE FODDERS — Con.										
(a) Meadow Grasses and Millets — Con.										
{ Black grass (<i>Juncus Gerardi</i>), }		2	5 {	50-62 56	-	67-71 69	53-63 58	50-66 59	46-59 52	37-51 44
{ Branch grass (<i>Distichlis spicata</i>), }		2	5 {	49-57 52	-	- 58	- 56	48-57 54	45-55 49	27-42 35
{ Flat sage (<i>Spartina stricta maritima</i> var.), }		1	3 {	55-58 57	-	61-62 62	50-55 52	60-61 60	54-57 55	33-40 36
{ Fox grass (<i>Spartina patens</i>), }		3	7 {	51-56 54	-	57-59 58	56-63 60	46-60 53	51-55 53	17-51 36
{ Salt hay mixture, fox and branch grasses, etc., }		1	2 {	52-56 54	-	68-70 69	41-43 42	54-61 58	51-54 52	26-30 28
{ Slough grass hay, Dakota, }		1	6 {	-	-	20-31 24	36-46 42	54-68 59	49-65 55	44-68 54
{ Timothy, in bloom, }		4	8 {	54-66 59	51-67 58	33-34 34	50-60 57	50-62 57	57-72 63	26-62 48
{ Timothy, past bloom, }		8	17 {	47-61 52	43-62 52	30-68 59	32-50 43	32-57 46	53-70 59	23-70 51
{ Timothy, stage unknown, }		1	4 {	57-62 59	57-62 59	47-54 50	38-41 40	-	-	-
{ Timothy, average all trials, }		24	58	55	56	39	48	50	62	50
{ Timothy fed with cottonseed meal (16 hay, 1 meal), }		1	2 {	52-56 54	-	17-28 22	24-32 28	46-52 49	61-63 62	36-37 36
{ Timothy fed with cottonseed meal (12 hay, 1 meal), }		1	2 {	49-55 52	-	9-30 20	27-38 32	43-51 47	58-62 60	52-64 53

Salt hays.

Timothy fed with cottonseed meal (8 hay, 1 meal),	1	2	{ 44—48 46	—	3—10 6	18—23 21	40—44 42	53—56 54	42—45 44
Timothy fed with cottonseed meal (4 hay, 1 meal),	1	2	{ 45—46 46	—	—	4—4 4	42—43 43	56—75 67	44—66 55
Timothy fed with cottonseed meal (2 hay, 1 meal),	1	2	{ 48—56 52	—	—	—	34—44 39	65—71 68	72—74 73
Timothy fed with cottonseed meal (1 hay, 1 meal),	1	2	{ 47—52 49	—	19—23 21	—	24—26 25	68—78 73	79—87 83
Timothy fed with cottonseed meal, average all trials,	6	12	50	—	16	20	41	62	57
Timothy and clover, poorly cured,	1	2	{ 54—55 55	—	—	37—38 38	52—54 53	—	—
Timothy and red top, late bloom,	1	7	{ 48—60 54	—	11—24 19	35—43 39	49—63 55	55—66 60	28—51 42
Western wheat grass (<i>agropyrum glaucum occidentale</i>),	1	6	{ —	—	2—30 14	42—61 51	62—74 68	55—69 61	31—49 39
Wyoming native hay, wire grass,	2	5	{ 51—64 57	—	31—55 42	33—60 47	56—66 61	53—65 56	53—63 58
Wyoming native hay, wheat grass,	4	9	{ 61—67 64	—	28—54 40	53—62 57	63—74 68	63—70 66	38—54 47
Witch grass (<i>Triticum repens</i>),	2	4	{ 60—63 61	61—64 62	—	49—64 58	56—68 62	62—70 66	54—60 57
(b) Cereal Fodders.									
Barley hay,	1	4	59	62	—	65	62	63	41
Corn fodder, dent, immature, average all trials,	6	15	{ 51—70 62	51—71 63	39—47 43	20—67 50	45—77 67	55—70 62	44—84 65
Corn fodder, dent, immature, B. & W.,	1	4	{ 51—64 57	—	—	20—36 27	45—74 59	57—66 61	66—84 76
Corn fodder, dent, in milk,	5	11	{ 59—66 63	—	—	44—51 50	50—71 64	61—69 66	67—79 75
Corn fodder, dent, mature,	10	30	{ 57—70 66	—	16—30 23	30—61 45	43—73 63	61—81 73	56—82 70

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY DRY AND COARSE FODDERS — Con.									
(b) <i>Cereal Fodders</i> — Con.									
Corn fodder, flint, ears forming,	1	3 {	69-72 70	71-73 71	-	69-73 70	72-73 72	71-73 71	63-71 67
Corn fodder, flint, mature,	5	11 {	63-73 70	-	-	56-79 64	69-80 76	63-78 71	59-79 71
Corn fodder, sweet, mature,	3	6 {	60-71 67	62-74 70	-	54-73 64	70-77 74	57-73 68	63-71 74
Corn stover, dent, Pride of the North,	1	2 {	53-55 54	-	29-33 31	45-45 45	53-63 61	53-55 54	63-66 65
Corn stover, Eureka silage, ears just forming,	2	4 {	54-64 59	-	40-46 43	57-58 53	56-72 65	53-64 59	62-67 65
Corn stover, average all trials,	12	33 {	53-64 57	49-58 55	29-46 41	11-58 37	52-74 64	53-64 59	36-77 69
Corn stover, below ear,	1	2 {	64-69 67	-	-	15-27 21	71-75 74	65-73 69	79-80 80
Corn stover, above ear,	1	2 {	52-58 55	-	-	17-27 22	69-72 71	50-57 54	62-65 64
Corn stover, minus pith (by hand),	1	3 {	54-57 55	55-59 57	-	16-28 20	60-65 63	55-58 57	70-75 72
Corn stover, minus pith, ground (Marsden's process),	1	3 {	63-64 63	-	46-55 49	57-62 60	60-61 61	65-66 66	82-83 83
Corn stover minus pith, ground (Marsden's process), steamed,	1	3 {	51-59 59	-	47-55 50	59-60 60	37-54 48	57-62 59	70-85 80
Corn stover, minus pith, average,	3	9 {	51-64 58	55-59 57	46-55 50	16-62 47	37-65 57	55-66 61	70-85 78

Corn stover, blades and husks,	1	4 {	60-68 65	-	15-35 23	41-55 48	67-76 73	64-71 66	53-64 58
Corn stover, tops and blades,	1	2 {	59-60 60	-	-	54-57 55	71-72 71	62-63 62	71-72 71
Corn stover, leaves,	1	2 {	55-56 56	-	-	43-69 56	54-67 61	57-61 59	61-65 63
Corn stover, leaves,	1	2 {	62-67 65	-	-	28-41 35	75-80 78	66-70 68	52-59 56
Corn stover, leaves, average both trials,	2	4 {	55-67 61	-	-	28-69 46	54-80 70	57-70 64	52-65 60
Corn stover, husks,	1	2 {	71-73 72	-	-	24-35 30	78-81 80	- 75	23-42 33
Kafir corn fodder,	1	4 {	59-62 61	-	5-11 8	34-42 38	56-63 60	64-68 66	57-67 61
Kafir corn stover, shredded,	1	4 {	54-58 56	-	13-26 19	29-34 30	65-69 67	56-60 58	77-81 79
Kafir corn stover,	1	1	63	-	43	50	67	67	60
Kafir corn stover, average both trials,	2	5	57	-	24	34	67	60	75
Oat hay, bloom to milk,	2	6 {	51-59 55	50-61 55	35-54 45	47-66 57	54-71 58	47-58 53	44-65 53
Oat hay, milk to dough,	4	14 {	48-60 54	48-61 54	20-54 37	34-60 52	30-62 48	49-62 56	52-72 64
Oat hay, average all trials,	6	20	54	54	39	53	51	55	60
Oat straw,	4	12 {	42-61 54	51-53 52	21-62 38	3-36 21	34-76 61	43-64 55	24-58 42
Sorghum fodder, Minnesota Early Amber,	1	3 {	58-60 58	54-55 54	41-49 44	40-47 43	42-56 49	57-67 61	62-67 65
Sorghum fodder, variety unknown,	1	6 {	-	-	9-55 23	30-74 53	57-84 71	49-82 64	66-87 77

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY AND DRY COARSE FODDERS — Con.									
(b) Cereal Fodders — Con.									
Sorghum fodder, leaves,	1	2 {	60-66 63	-	-	59-62 61	65-76 70	62-67 65	46-47 47
Sorghum fodder, bagasse,	1	1	61	-	-	14	64	65	46
(c) Legumes.									
Alfalfa, first crop,	19	33 {	55-72 63	-	34-67 54	61-85 75	19-65 47	61-79 72	23-65 43
Alfalfa, second crop,	13	27 {	54-67 63	-	35-59 52	64-81 77	40-53 46	65-80 74	14-51 42
Alfalfa, third crop,	1	2 {	56-60 58	-	40-49 44	68-70 69	28-40 34	71-71 71	38-45 42
Alfalfa, poor quality,	1	2 {	56-56 56	58-58 58	35-44 39	66-66 66	38-43 40	68-72 70	31-45 38
Alfalfa, stage of cutting unknown,	1	2 {	54-55 55	-	24-25 25	67-70 69	40-42 41	68-70 69	13-19 16
Alfalfa, stage of cutting unknown,	1	6 {	-	-	31-40 35	74-80 78	40-50 44	65-77 72	33-42 37
Alfalfa, average all trials,	42	80	62	-	50	74	46	72	40
Soy bean,	1	2 {	62-63 62	-	-	70-72 71	59-62 61	66-71 69	19-40 29
Clover, alsike, full to late bloom,	4	9 {	55-64 59	56-65 60	-	64-71 66	40-59 50	59-74 66	21-69 38
Clover, crimson,	3	9 {	57-65 62	52-58 56	-	64-73 69	32-53 45	52-74 62	29-54 44

Clover, red, bud to early blossom,	1	2	{ 63—64 64	—	59—61 60	64—64 64	57—62 59	67—68 68	52—52 52
Clover, red, full blossom,	1	2	{ 58—61 60	—	54—58 56	59—61 60	43—49 46	68—71 69	55—56 55
Clover, red, stage of cutting not given,	10	21	{ 49—67 58	51—66 55	0—44 32	47—69 57	42—70 54	56—72 65	40—70 56
Clover, red, average all trials,	12	25	58	55	36	58	54	65	56
Clover, white,	1	1	66	67	—	73	61	70	51
Clover, rowen,	2	4	—	58—60 59	42—50 46	60—69 65	45—51 47	62—64 63	58—60 60
Sweet clover,	1	3	{ 58—62 61	—	65—67 66	75—76 75	27—37 34	71—73 72	28—33 31
Pea straw,	1	3	{ 65—69 67	—	27—37 33	76—80 78	48—54 51	78—80 79	47—51 50
Cow pea,	1	2	{ — 59	—	—	64—65 65	41—45 43	— 71	46—54 50
Peanut vine,	1	2	{ 59—60 60	—	—	63—64 63	51—53 52	69—70 70	62—70 66
French pea (<i>Lathyrus</i> —),	1	2	{ 67—68 68	—	65—69 67	81—82 82	49—50 49	75—76 75	58—60 59
Spring vetch (<i>Vicia sativa</i>),	2	4	{ 64—67 66	66—68 67	52—60 56	61—71 66	54—61 58	70—72 72	68—72 70
Winter or hairy vetch (<i>Vicia villosa</i>),	2	8	{ 59—71 67	—	34—67 47	68—83 82	51—63 58	62—75 67	53—74 67
(d) Mixed and Miscellaneous.									
Buttercups (<i>Ranunculus acris</i>),	1	2	56	57	—	56	41	67	70
Cottonseed feed (4-1), ¹ sheep,	2	6	{ 54—60 56	—	23—25 28	36—45 41	51—60 56	57—60 59	86—94 91
Cottonseed feed (4-1), steers,	1	2	54	—	46	54	45	58	85

¹ Four hulls to one meal.

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen- free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY AND DRY COARSE FODDERS — Con.									
(d) Mixed and Miscellaneous — Con.									
Cottonseed feed, average both (4-1) trials,	3	8	56 42-60 49	-	33 20-46 31	44 32-54 42	53 28-54 50	59 50-67 60	90 83-94 88
Cottonseed feed (5-1) steers,	2	5	{	-	-	-	-	-	-
Cottonseed feed (7-1) and (8-1), steers,	1	3	{ 45-46 46	-	28	44-46 45	34-40 37	50-51 50	81-82 82
Cottonseed feed (3-1) to (2-1), steers,	2	9	54	-	32	64	47	54	85
Cottonseed feed, average all trials,	8	25	53	-	31	51	47	56	87
Cottonseed hulls,	4	13	{ 35-47 41	-	-	0-25 6	.5-58 47	13-46 34	58-59 79
Oats and peas,	2	7	{ 56-67 61	56-67 60	54-65 58	69-78 73	50-64 58	54-66 61	51-69 59
Oats and sand vetch,	1	2	{ 55-55 55	56-56 56	43-46 44	64-66 65	48-50 49	58-59 59	58-67 63
Oats and spring vetch,	2	5	{ 57-63 59	-	-	60-71 65	47-67 57	34-65 59	17-76 52
Oats and vetch, average,	3	7	58	58	56	65	55	59	55
Salt bush (<i>Atriplex Argentea</i>),	1	3	{ 46-47 46	31-32 31	71-72 72	65-68 66	3-15 8	46-51 49	50-55 52
Wheat and sand vetch, blossom,	2	6	{ 64-69 66	-	33-60 47	70-77 74	63-66 65	67-71 68	62-67 64
White weed (<i>Leucanthemum vulgare</i>),	1	2	58	58	-	58	46	67	62
Willows (<i>Salix exigna</i>),	1	2	{ 50-53 54	-	24-40 32	20-38 29	40-44 42	63-70 67	73-67 70

IV. ROOTS AND TUBERS.

Sugar beets,	1	2 {	94-95 99	98-100 99	-	90-93 91	88-113 100	100-100 100	40-53 50
Mangolds,	1	2 {	77-80 79	83-87 85	-	70-80 75	27-59 43	91-92 91	-
Potatoes,	1	3 {	73-80 77	75-81 78	-	43-45 44	-	87-93 91	- 13
Ruta-bagas,	1	2 {	84-90 87	89-93 91	-	75-86 80	61-87 74	94-95 95	77-92 84
English flat turnips,	1	2 {	91-95 93	98-99 96	-	84-95 90	89-117 100	96-97 97	82-92 88

V. CONCENTRATED FEEDSTUFFS.

(a) Protein.

Soy bean meal, variety unknown,	2	3 {	75-79 78	-	-	89-91 90	0-73 33	68-73 71	81-98 89
Soy bean meal, medium green, coarse ground,	2	4 {	81-98 90	-	42-77 57	88-95 91	-	61-100 81	89-97 93
Bibby's dairy cake,	2	6 {	61-81 70	-	18-44 33	58-76 66	1-68 46	71-88 81	84-99 92
Bile's Union Grains,	2	3 {	72-94 81	-	22-70 39	69-86 76	78-118 93	75-98 86	95-102 98
Blood meal, Armour's,	1	2 {	-	-	-	80-88 84	-	-	-
Brewers' dried grains,	2	5 {	56-62 62	-	-	78-84 81	28-62 49	51-60 57	87-93 89
Buckwheat middlings,	1	3 {	71-79 75	-	26-41 36	83-86 85	8-26 17	79-87 83	87-92 89
Buffalo Creamery Feed,	1	2 {	68-71 69	-	20-25 23	80-82 81	52-57 55	70-72 71	83-91 87
Chapins Alfalfa Meal, a dairy feed,	1	2 {	52-67 59	-	13-40 26	67-75 71	31-58 45	56-70 63	76-92 84

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. CONCENTRATED FEEDSTUFFS — Con.									
(a) <i>Proteins</i> — Con.									
Cottonseed, raw,	1	2 {	63—69 66	-	-	66—70 68	65—86 76	49—50 50	- 87
Cottonseed, roasted,	1	2 {	53—58 56	-	-	44—50 47	62—69 66	50—53 51	68—75 72
Cottonseed meal,	4	12 {	67—90 79	81—95 88	-	76—96 84	26—55 35	66—96 78	87—100 94
Cottonseed meal, high grade (Maine),	1	2	90	95	-	83	-	96	100
Cottonseed meal, medium grade (Maine),	1	2 {	67—79 73	73—83 78	-	81—86 84	40—47 44	73—91 82	95—95 95
Cottonseed meal, low grade (Maine),	1	2 {	60—63 62	62—67 65	-	72—73 73	30—45 38	66—70 68	87—93 90
Cottonseed meal, low grade (Massachusetts),	1	2 {	60—76 68	-	80—89 85	77—80 78	- 40	73—83 78	100—100 100
Cottonseed meal, high grade, dark colored, slightly fermented (Maine).	1	2 {	81—91 86	85—95 90	-	82—83 83	-	90—100 95	95—100 98
Dairy feed, H-O,	2	4 {	65—65 65	-	-	68—80 76	14—43 35	67—75 72	83—88 84
Distillers' dried grains, largely from rye,	1	2 {	56—59 58	-	-	56—63 59	-	61—73 67	80—88 84
Distillers' dried grains, largely from corn,	8	17 {	70—89 79	-	-	66—80 73	59—100+ 95	69—97 81	88—98 95
Germ oil meal,	2	5 {	72—83 76	-	-	65—77 73	-	68—82 76	95—98 96

Gluten feed,	10	18 {	85-98 88	92-93 93 ²	78-99 88 ³	69-93 85	64-100+ 87	83-97 90	60-83 81
Gluten meal,	4	8 {	75-95 87	-	-	86-93 88	-	78-94 88	91-99 93
Linseed meal, old process,	1	3 {	75-82 79	-	-	86-93 89	38-71 57	76-79 78	85-92 89
Linseed meal, new process,	1	3 {	73-83 78	-	-	82-88 85	49-100 74	82-87 84	90-98 93
Linseed meal, new process, Cleveland flax,	3	9 {	76-88 83	-	-	-	-	-	-
Linseed meal, new process, average,	4	12	82	79	-	83	-	79	87
Malt sprouts,	1	1	67	68	-	84	74	80	89
Malt sprouts (Massachusetts),	1	3 {	75-89 82	-	3-33 19	74-77 76	98-100 99	76-91 85	74-100 87
Maize feed (Chicago),	1	2 {	83-85 84	-	-	83-84 84	68-76 72	84-87 85	90-90 90
Oat middlings, fine,	1	2 {	88-91 90	-	31-40 36	80-81 81	21-77 49	94-97 96	93-94 94
Pea meal,	1	2 {	85-88 87	86-89 88	-	80-86 83	25-26 26	93-94 94	52-57 55
Protina Dairy Feed,	1	2 {	63-66 65	-	33-37 35	70-73 72	33-45 39	72-76 74	97-99 98
Cow pea meal,	1	2 {	85-88 87	-	22-45 33	80-85 82	62-66 64	92-94 93	74-74 74
Rye feed, bran and middlings,	1	3 {	77-83 82	-	25-48 35	78-82 80	-	86-89 88	79-99 90
Unicorn Dairy Ration,	2	3 {	81-87 83	-	6-40 25	73-77 76	62-84 72	86-94 89	95-96 96

¹ One trial.² Average thirteen trials.³ Average two trials.

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. CONCENTRATED FEEDSTUFFS — Con.									
(a) Protein — Con.									
Wheat bran, spring,	3	7 {	69—70 67	69—74 71	20—32 25	74—82 76	22—76 44	70—80 74	38—83 63
Wheat bran, winter,	1	3 {	57—66 62	—	—	75—79 77	— 27	62—76 65	51—80 64
Wheat bran, average all trials,	4	10	66	—	—	77	39	71	63
Wheat feed flour,	1	2 {	67—67 67	70—70 70	—	78—80 79	—	73—78 76	—
Wheat middlings, flour,	2	4 {	78—86 82	81—84 83	—	82—91 88	33—40 36	84—91 88	82—88 86
Wheat middlings, standard,	2	6	—	73	25	77	30	78	88
Wheat mixed feed, bran and middlings,	2	4 {	71—78 73	73—81 76	34—43 37	77—79 78	47—79 62	74—79 77	81—92 87
Wheat mixed feed, adulterated with corn cobs,	1	3 {	59—65 62	61—67 64	28—34 31	62—63 63	17—36 28	68—74 71	91—93 92
Wheat screenings,	1	2 {	70—87 79	—	—	68—81 75	45—85 65	81—89 85	92—95 94
(b) Starchy.									
Feed barley meal,	1	2 {	87—91 89	—	28—47 38	86—90 88	45—96 70	92—94 93	86—87 86
Hanna barley,	3	13 {	—	—	—	68—90 77	15—98 56	87—96 92	55—99 78
Manchuria barley,	1	2 {	—	—	—	84—84 84	— 54	89—93 91	78—82 80

Cerealine feed,	1	3 {	89-92 90	-	-	79-81 80	72-92 82	93-97 95	78-83 81
Chop feed, corn bran and germs,	2	6 {	71-92 80	-	-	56-77 67	54-70 62	64-92 84	61-86 82
Corn bran,	2	4 {	70-71 70	-	-	53-55 54	50-65 59	74-80 77	69-85 77
Corn cobs,	1	2 {	59-60 59	-	-	13-22 17	65-66 65	60-80 60	44-56 50
Corn meal, coarse,	2	4 {	74-93 84	75-94 86	-	45-54 48	-	79-91 86	-
Corn meal, fine,	5	8 {	84-90 87	89-90 90	-	48-81 65	-	87-98 98	75-95 85
Corn meal, average all trials,	12	26 {	74-98 88	75-94 90	-	40-87 67	-	79-100 92	71-99 90
Corn and cob meal,	1	3 {	74-83 79	-	-	43-65 52	2-86 45	86-91 88	82-85 84
Corn and oat feed, Victor,	1	3 {	74-76 75	-	-	66-75 71	36-58 48	81-85 83	84-88 87
Kafir corn kernels,	2	6 {	29-58 43	-	-	28-54 41	-	34-62 45	-
Kafir corn meal,	3	7 {	54-81 70	-	38-99 69	36-65 56	61 ² -	67-88 79	25-81 55
White Kafir corn heads,	1	4 {	14-35 24	-	24-83 54	7-23 12	0-46 27	14-40 31	5-65 31
Dairy feed, Quaker,	3	8 {	58-64 62	52	-	62-72 70	54-56 55	55-71 59	72-80 74
Hominy meal,	3	8 {	71-91 82	-	11-60 37	54-74 65	2-100+ 67	82-94 89	88-95 92
Horse feed, H-O,	3	5 {	70-77 74	78	-	62-81 70	52-59 56	79-85 83	74-87 80

¹ Average three trials.² Average five trials.³ One trial.

EXPERIMENTS WITH RUMINANTS — Concluded.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
<i>V. CONCENTRATED FEEDSTUFFS — Con.</i>									
Milo maize meal,	1	2 {	77—91 84	—	84—100 92?	61—71 66	— 100	83—86 85	87—94 90
(b) <i>Starchy</i> — Con.									
Alma dried molasses beet pulp,	1	2 {	82—87 85	—	55—69 62	50—69 64	83—84 84	89—93 91	—
Blomo feed,	1	2 {	64—69 67	—	31—32 32	61—64 63	51—72 61	73—79 76	14—17 16
Green Diamond sugar feed,	1	2 {	61—70 66	—	36—39 38	68—72 70	36—52 44	70—78 74	75—92 84
Holstein sugar feed,	1	3 {	70—74 71	—	24—43 33	61—71 66	26—62 44	79—82 81	86—89 88
Macon sugar feed,	1	2 {	69—72 71	—	20—21 20	57—61 59	36—51 44	81—83 82	74—91 82
Sucrene dairy feed,	1	2 {	67—72 69	—	28—47 38	57—64 61	70—73 72	71—75 73	93—96 95
Molasses feeds, average last four,	4	9	69	—	32	64	50	79	87
Red Orenburg millet,	2	4 {	—	—	—	39—64 55	24	84—95 88	86—91 88
Black Voronezh millet,	4	8 {	—	—	—	54—93 70	14—65 30	76—95 88	68—91 81
Sixty day oats,	1	1	—	—	—	86	50	86	79
Swedish select oats,	4	11 {	—	—	—	67—85 77	16—55 36	76—87 81	82—97 89
Oats, unground,	2	6 {	66—74 70	63—74 71	2—61 25	72—81 77	15—40 31	74—79 77	87—92 89

Molasses feeds.

Oat feed, Royal, many bulls,	1	3 {	42-51 47	42-53 48	33-40 37	64-72 69	20-43 33	50-54 51	86-92 88
Oat feed, excessive bulls,	1	3 {	29-38 34	-	8-21 13	51-69 62	25-37 32	29-36 33	89-97 92
Oat feed, average last two,	2	6 {	40	-	25	65	32	42	90
Parson's "Six-dollar" feed, mill sweepings,	1	2 {	55-56 56	-	10-14 12	56-62 59	45-50 47	63-65 64	80-81 81
Peanut feed, largely husks,	1	2 {	32-32 32	-	-	70-71 71	10-13 12	41-58 49	90-90 90
Rice meal,	1	2 {	71-76 74	-	-	-	-	89-95 92	91-92 91
Rice bran,	1	2 {	56-66 62	-	1-34 18	58-68 64	13-42 21	76-81 78	52-92 72
Rye meal,	1	2 {	85-90 87	-	-	83-85 84	-	89-94 92	63-65 64
Rice polish,	1	2 {	82-83 83	-	27-36 31	65-66 66	22-23 22	92-93 93	66-81 74
Speltz or emmer, unground (Minnesota),	1	2 {	93-94 94	-	51-56 53	85-88 87	82-85 84	96-97 97	90-94 92
Speltz or emmer (South Dakota),	3	9 {	-	-	-	68-85 78	42-60 50	81-95 87	74-99 87
Speltz or emmer, average,	4	11 {	-	-	-	80	60	89	88
Schumacher's stock feed (corn, oat and barley),	1	2 {	70-72 71	-	-	68-72 70	46-59 52	79-79 79	87-89 88
Durum wheat,	1	2 {	-	-	-	76-80 78	40	92-92 92	61-69 65
Red wheat meal,	1	2 {	82-88 86	-	26-29 28	66-68 67	40	91-94 92	79-81 80
White Winter wheat meal,	1	2 {	86-91 88	-	10-49 30	81-83 82	77	92-95 93	62-66 64

EXPERIMENTS WITH SWINE.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein ¹ (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
Barley meal,	1	1	80	80	-	81	49	87	57
Linseed meal, old process,	1	4 {	76-79 77	-	8-12 10	83-90 86	10-14 12	82-87 85	78-82 80
Maize kernels,	1	1	83	83	-	69	38	89	46
Maize meal,	2	2 {	89-90 90	91-92 92	-	86-90 88	29-49 39	94-94 94	78-82 80
Maize meal with cobs,	1	1	76	77	-	76	29	84	82
Hog millet seed (<i>Panicum milia ceum</i>),	1	1	73	-	19	68	33	92	59
Pea meal,	1	1	90	92	-	89	78	95	50
Potatoes,	1	4	97	-	-	84	-	98	-
Wheat, whole,	1	?	72	-	-	70	30	74	60
Wheat, cracked,	1	?	82	-	-	80	60	83	70
Wheat shorts (middlings),	1	2 {	74-79 77	-	-	71-75 73	25-48 37	85-88 87	-
Wheat bran,	1	2 {	54-78 66	-	-	74-76 75	30-39 39	56-75 66	65-78 72

EXPERIMENTS WITH HORSES.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen- free Extract (Per Cent.).	Crude Fat (Per Cent.).
Corn kernels,	1	2 {	71-78 74	-	20-32 26	40-76 58	-	85-92 88	43-52 48
Corn meal, same as above,	1	2 {	84-93 88	-	-	74-77 76	-	93-99 96	70-76 73
Corn stover minus pith, ground (Marsden's process),	1	2 {	40-59 50	-	6-37 22	65-70 68	38-71 55	39-54 47	48-72 60
Oat kernels,	1	2 {	67-77 72	-	31-36 33	84-87 86	13-49 31	75-83 79	80-85 82
Oats, ground, same as above,	1	2 {	73-78 76	-	9-49 29	81-83 82	.6-23 14	85-87 86	79-81 80
Oats, average,	2	4	74	-	31	84	22	82	81
Timothy hay,	1	2 {	39-48 44	-	29-39 34	18-24 21	37-48 43	44-50 47	44-51 47

EXPERIMENTS WITH POULTRY.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
Clover, second crop, just beginning to blossom,	1	3	-	28	-	71	10	14	36
Corn kernels,	1	3	-	86	-	44-58 50	-	90-96 92	88-95 92
Corn kernels,	2	6	-	86-87 87	-	68-87 81	1-25 15	88-92 90	81-87 85
Corn, cracked,	1	2	-	83-84 83	-	72-73 72	-	87-89 88	87-88 87
Corn meal,	1	3	-	85	-	41-55 48	-	91-92 91	92-94 93
Corn meal,	1	2	-	82-84 83	-	72-77 75	-	84-88 86	87-88 88
Kafir corn kernels,	1	3	-	88	-	50-55 53	17-22 20	94-98 96	71-73 74
Kafir corn meal,	1	3	-	87	-	42-44 43	30-42 35	95-97 96	82-84 83
Meat,	1	2	-	87-87 87	-	90-91 91	-	-	86-87 87
Beef scrap,	1	2	-	80	-	93	-	-	96
Oats, whole,	2	12	-	59-68 63	-	68-84 75	4-11 81	62-75 69	77-89 83
Oats, rolled,	1	2	-	79-84 82	-	78-81 80	-	85-87 86	86-102 94
Cow peas,	1	3	-	71	-	32-48 40	2-43 18	86-88 87	87-90 89

Cow pea meal,	1	3	—	—	—	40—49 44	8—11 10	84—91 88	75—98 89
Wheat,	1	1	—	—	84	77	—	89	59
Wheat, hard,	1	1	—	—	82	71	—	81	57
Wheat, soft,	1	5	—	—	81—85 82	57—79 74	—	87—90 89	45—69 54
Wheat bran, coarse,	1	3	—	—	46—47 47	69—74 72	13—14 14	40—46 46	35—38 37
India wheat,	1	3	—	—	67—76 73	71—80 75	5—29 21	79—86 83	79—87 84

EXPERIMENTS WITH CALVES.

Whole milk,	2	8	—	—	—	90—98 95	—	—	93—99 97
Pasteurized whole milk,	2	9	—	—	—	88—95 93	—	—	91—99 95
Cooked whole milk,	1	3	—	—	—	80—94 87	—	—	92—99 95
Raw skim milk,	1	3	—	—	—	94—95 95	—	—	—
Skim milk, with sheep,	1	3	96—102 97	—	—	46—74 62	—	—	—
			100	—	—	93—96 94	—	100	100

1 Eight trials.

AVERAGE DIGESTION COEFFICIENTS OBTAINED WITH POULTRY.¹

[German and American Experiments.]

KIND OF FODDER.	Number of Experi- ments.	Organic Matter.	Crude Protein.	Nitrogen- free Extract.	Fat.
Bran, wheat,	3	46.70	71.70	46.00	37.00
Beef scrap,	2	80.20	92.60	—	95.00
Beef (lean meat),	2	87.65	90.20	—	86.30
Barley,	3	77.17	77.32	85.09	67.86
Buckwheat,	2	69.38	59.40	86.99	89.22
Corn, whole,	16	86.87	81.58	91.32	88.11
Corn, cracked,	2	83.30	72.20	88.10	87.60
Corn meal,	2	83.10	74.60	86.00	87.60
Clover,	3	27.70	70.60	14.30	35.50
India wheat,	3	72.70	75.00	83.40	83.80
Millet,	2	—	62.40	98.39	85.71
Oats,	13	62.69	71.31	90.10	87.89
Peas,	3	77.07	87.00	84.80	80.01
Wheat,	10	82.26	75.05	87.04	53.00
Rye,	2	79.20	66.90	86.70	22.60
Potatoes,	6	78.33	46.94	84.46	—

¹ Compiled by J. M. Bartlett, Bulletin 184, Maine Agricultural Experiment Station.

LITERATURE.

The following publications have been consulted in compiling the foregoing tables of digestibility: —

Colorado Experiment Station, Bulletins 8, 93.

Connecticut (Storrs) Experiment Station, reports for 1894–96, 1898; Bulletin 43.

Illinois Experiment Station, Bulletins 43, 58.

Kansas Experiment Station, Bulletin 103.

Louisiana Experiment Station, Bulletin 77, second series.

Maine Experiment Station, reports for 1886–91, 1893, 1894, 1897, 1898, 1900; Bulletins 110, 184.

Maryland Experiment Station, Bulletins 20, 41, 43, 51, 77, 86.

Massachusetts Agricultural Experiment Station, reports for 1895–99, 1901–05, 1907; and Digestion Experiments, Series XII., XIII., XIV., XV., unpublished.

Massachusetts, State Experiment Station, reports for 1893, 1894.

Minnesota Experiment Station, reports for 1894–96; Bulletins 26, 36, 42, 47, 80, 99.

Mississippi Experiment Station, report for 1895.

Nevada Experiment Station, Bulletins 64, 66, 71.

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North Carolina Experiment Station, Bulletins 80*c*, 81, 87*d*, 97, 118, 148, 160, 172.

Oklahoma Experiment Station, Bulletins 37, 46.

Oregon Experiment Station, Bulletins 6, 47, 85, 102.

Pennsylvania Experiment Station, reports for 1887–94, 1897, 1898, 1900–01, 1903–04, 1906–07.

South Dakota Experiment Station, Bulletin 114.

Tennessee Experiment Station, unpublished data.

Texas Experiment Station, Bulletins 13, 15, 19, 104.

Utah Experiment Station, Bulletins 16, 54, 58.

United States Department of Agriculture, Bureau of Animal Industry, Bulletins 56, 106.

Wisconsin Experiment Station, report for 1889; Bulletin 3.

Wyoming Experiment Station, Bulletins 69, 78.

TABLE V.—COMPILATION OF ANALYSES OF AGRICULTURAL CHEMICALS, REFUSE SALTS, PHOSPHATES, GUANOS, ASHES, LIME COMPOUNDS, MARLS, BY-PRODUCTS, REFUSE SUBSTANCES AND ANIMAL EXCREMENTS.

H. D. HASKINS AND L. S. WALKER.

- A. CHEMICALS AND REFUSE SALTS.
 - (a) Nitrogen chemicals.
 - (b) Potash chemicals.
 - (c) Refuse salts.
- B. PHOSPHATES AND GUANOS.
 - (a) Natural phosphates.
 - (b) Dissolved phosphates.
 - (c) Guanos.
- C. ASHES, LIME COMPOUNDS AND MARLS.
 - (a) Ashes.
 - (b) Lime compounds.
 - (c) Marls.
- D. BY-PRODUCTS AND REFUSE SUBSTANCES.
 - (a) Abattoir products.
 - (b) Fish products.
 - (c) Seaweeds.
 - (d) Vegetable products.
 - (e) Wool products.
 - (f) Miscellaneous substances unclassified.
- E. ANIMAL EXCREMENTS.
- F. INSECTICIDES.

As a rule, the analyses reported in the following compilation were made at this laboratory.¹ Some of them were made many years ago. Refuse products from various manufacturing industries are likely to vary more or less in composition, due to frequent changes in the parent industry. The revision of the

¹ In the compilation of analyses of seaweeds, five of said analyses were taken from Bulletin No. 21 of the Rhode Island Agricultural Experiment Station.

compilation every five years, however, insures quite reliable figures in most instances. In case of the agricultural chemicals and by-products which are commonly known to the fertilizer trade, the present compilation includes the samples collected by our inspectors during the last five years, as well as those samples sent by farmers and farmer organizations. In all cases where samples are forwarded for analysis, they are taken according to printed directions furnished from this office, which is a reasonable assurance that the analyses are representative of the materials sampled. In many instances extremely wide variations occur in different analyses of the same product. This emphasizes the importance of careful sampling as well as the purchase of such materials on a specific guarantee of plant food which they furnish.

In the majority of instances only the highest, lowest and average percentage of nitrogen, potash and phosphoric acid are given in the tables, but it should be remembered that blanks do not imply the absence of the other ingredients.

A. CHEMICALS AND REFUSE SALTS.

[Figures equal percentages or pounds in 100.]

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.			Soluble Phos- phoric Acid.	Reverted Phos- phoric Acid.	Insoluble Phos- phoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.	
				NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.														
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.												
(a) Nitrogen Chemicals.																								
Calcium cyanide,	3	.71	-	-	19.06	-	-	-	-	-	-	-	-	-	-	63.19	-	2.10	-	-	-	-	1.00
Carbonate of ammonia,	1	-	-	-	22.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.74	-	-
Nitrate of potash,	10	1.58	-	14.58	11.42	12.57	45.62	43.48	44.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate of soda,	186	1.76	-	16.57	14.14	15.38	-	-	-	-	-	-	-	-	35.50	-	-	-	-	-	.50	.50	-
Nitrate of lime,	1	5.88	-	-	-	12.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrogenous chalk,	4	.78	-	9.88	8.42	9.11	-	-	-	-	-	-	-	-	-	29.30	-	-	-	-	-	-	2.28
Phosphate of ammonia,	1	6.05	-	-	-	10.87	-	-	-	-	-	-	-	-	-	-	-	-	12.46	-	-	-	.82
Sulfate of ammonia,	35	1.01	-	22.72	19.44	20.91	-	-	-	-	-	-	-	-	-	-	-	-	60.00	-	-	-	-
(b) Potash Chemicals.																								
Carbonate of potash, high grade,	26	2.25	-	-	-	-	57.20	55.68	63.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate of potash and magnesia,	2	18.22	-	-	-	-	20.00	18.48	19.24	-	-	-	-	-	-	-	19.52	-	-	-	-	.39	-
Carnallite,	1	-	-	-	-	-	-	-	13.68	-	-	-	-	-	-	7.66	-	13.19	.56	-	41.56	-	-
Hard salts,	1	.45	-	-	-	-	-	-	17.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kainit,	24	3.04	-	-	-	-	16.50	10.90	13.07	-	-	-	-	-	-	18.97	2.37	6.37	20.25	-	20.64	2.13	-
Krugite,	1	4.82	-	-	-	-	-	-	8.42	-	-	-	-	-	-	5.27	12.45	8.79	31.94	-	6.63	14.96	-

Muriate of potash,	134	1.50	-	-	-	58.08	43.08	49.82	-	-	-	-	-	-	6.69	-	.55	-	-	-	48.80	.70
Phosphate of potash,	1	3.76	-	-	-	-	-	32.55	-	-	-	37.50	-	-	-	-	-	-	13.43	-	-	.92
Sulfate of potash, high grade,	113	.90	-	-	-	53.60	45.40	49.69	-	-	-	-	-	-	4.46	-	1.50	-	45.72	-	-	.75
Sulfate of potash and magnesia,	52	4.65	-	-	-	31.68	19.55	26.37	-	-	-	-	-	-	6.25	2.57	13.65	-	44.62	-	1.92	2.26
Silicate of potash,	5	8.26	-	-	-	27.62	18.62	20.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vegetable potash,	11	3.40	-	-	-	27.84	23.96	25.59	-	-	-	2.55	-	-	-	20.65	-	-	-	-	-	9.70
(c) <i>Refuse Salts.</i>																						
Cyanide of potash refuse,	1	39.23	-	-	-	.96	-	7.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Niter salt cake,	2	6.03	-	-	-	2.29	-	.87	-	-	-	-	-	-	29.56	-	-	-	47.77	-	-	3.92
Sulfate of magnesia,	12	24.51	-	-	-	-	-	-	-	-	-	-	-	-	-	2.82	17.18	-	36.10	-	-	5.73
Sulfate of soda,	1	1.38	-	-	-	-	-	-	-	-	-	-	-	-	45.50	-	-	-	59.43	-	-	-
Salt-peter waste,	27	3.63	-	-	-	10.12	.52	3.41	50.94	1.55	24.82	-	-	-	37.04	.79	.19	-	1.85	-	44.37	-

B. PHOSPHATES AND GUANOS.

[Figures equal percentages or pounds in 100.]

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.			Soluble Phos- phoric Acid.	Reverted Phos- phoric Acid.	Insoluble Phos- phoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.	
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.												
(a) Natural Phosphate.																								
Apatite,	2	.07	-	-	-	-	-	-	-	37.74	32.62	35.18	-	2.09	33.09	-	-	-	-	-	-	-	-	-
Arkansas rock phosphate,	1	.91	-	-	-	-	-	-	-	-	-	25.10	-	-	-	-	-	-	-	-	-	-	-	-
Belgian phosphate,	1	.21	-	-	-	-	-	-	-	-	-	9.54	-	-	-	41.27	-	-	-	-	-	-	-	-
Bone ash,	13	3.09	-	-	-	-	-	-	-	39.14	28.38	35.96	-	4.07	31.89	-	52.12	-	-	-	-	-	-	.96
Bone black,	5	4.60	-	-	-	-	-	-	-	30.54	16.56	28.28	-	-	-	-	-	-	-	-	-	-	-	3.64
Brockville phosphate,	1	2.50	-	-	-	-	-	-	-	-	-	35.21	-	-	-	-	-	-	-	-	-	-	-	6.46
Florida rock phosphate,	2	.53	-	-	-	-	-	-	-	40.34	33.10	36.72	-	.10	36.62	-	-	-	-	-	-	-	-	-
Florida soft phosphate,	2	5.22	-	-	-	-	-	-	-	-	-	23.24	-	.85	22.40	-	-	-	-	-	-	-	-	-
Novassa phosphate,	1	5.77	-	-	-	-	-	-	-	-	-	24.56	-	1.66	22.90	-	-	-	-	-	-	-	-	-
South American bone ash,	1	7.00	-	-	-	-	-	-	-	-	-	35.89	-	-	-	-	44.89	-	-	-	-	-	-	4.50
South Carolina rock phosphate,	12	1.36	-	-	-	-	-	-	-	31.87	20.60	26.62	-	3.40	24.60	-	-	-	-	-	-	-	-	-
Tennessee phosphate,	1	1.09	-	-	-	-	-	-	.44	-	-	27.97	-	-	-	-	-	-	-	-	-	-	-	-
(b) Dissolved Phosphates.																								
Acid phosphate,	97	10.49	-	-	-	-	-	-	-	19.44	11.60	16.07	9.53	4.62	1.92	-	-	-	-	-	-	-	-	-
Basic slag phosphate,	42	.68	-	-	-	-	.52	.04	.38	-	-	18.08	-	14.17	2.79	-	44.33	-	-	16.18	-	2.51	-	9.14

Dissolved bone,	27	8.09	-	-	-	2.57	-	-	24.12	14.58	16.84	3.49	9.37	3.98	-	-	-	-	-	-
Dissolved bone black,	67	11.09	-	-	-	-	-	-	21.14	14.69	17.40	12.24	4.04	1.12	-	-	-	-	-	-
Double super phosphate,	2	6.27	-	-	-	-	-	-	50.14	45.42	47.78	18.36	20.97	8.45	-	-	-	-	-	-
Precipitated phosphate,	1	9.40	-	-	-	-	-	-	-	-	25.45	.72	24.17	.56	-	-	-	-	-	-
Upton phosphate,	1	9.07	-	-	-	-	-	-	-	-	40.15	-	37.84	2.31	-	-	-	-	-	-
(c) <i>Guanos.</i>																				
Guano, bat (Texas),	9	40.09	18.24	10.51	2.58	6.47	-	-	1.31	6.53	1.00	3.76	-	-	-	-	-	-	-	2.00
Guano, bat (Florida),	2	15.66	-	-	-	9.74	-	-	1.77	3.44	3.26	3.35	-	-	-	-	-	-	-	19.33
Guano, bat (Havana, Cuba),	2	5.83	-	6.96	1.70	4.33	1.20	.53	.86	14.00	5.04	9.52	-	-	6.17	11.04	-	-	-	9.47
Guano (Cuban),	5	24.27	-	2.74	.63	1.67	-	-	-	16.16	11.54	13.35	-	-	-	-	-	-	-	3.17
Guano, Caribbean (Orechilla),	12	7.31	-	-	-	-	-	-	-	35.43	18.14	26.77	-	-	-	39.95	3.29	-	2.68	1.27
Guano (Damaraland),	1	17.70	-	-	-	5.79	-	-	3.53	-	-	14.78	4.90	5.79	4.09	7.03	14.21	2.05	5.94	5.76
Guano, Mona Island,	1	13.32	-	-	-	.76	-	-	-	-	-	21.88	-	7.55	14.33	-	37.49	-	-	2.45
Guano, Peruvian,	30	13.58	37.61	13.50	4.44	6.36	4.08	1.14	2.62	20.60	5.96	14.85	3.72	5.49	5.64	-	12.85	-	-	6.60
Guano, rat (Florida),	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	1.15

C. ASHES, LIME COMPOUNDS AND MARLS.
[Figures equal percentages or pounds in 100.]

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.			Soluble Phos- phoric Acid.	Reverted Phos- phoric Acid.	Insoluble Phos- phoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.	
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.												
(a) Ashes.																								
Ashes, bamboo,	1	31.84	-	-	-	-	-	-	1.92	-	-	1.80	-	-	-	-	1.56	-	-	-	-	-	-	-
Ashes, bituminous coal,	2	3.66	-	-	-	-	-	-	.38	-	-	.44	-	-	-	1.88	-	-	-	-	-	-	74.17	
Ashes, brick-yard,	2	.58	-	-	-	-	3.59	3.32	3.45	1.61	1.33	1.47	-	-	-	24.33	-	-	-	-	-	-	47.63	
Ashes, blue works,	1	12.14	63.78	-	-	-	-	-	9.02	-	-	-	-	-	-	-	-	-	-	-	-	-	12.30	
Ashes, corn-cob,	2	5.47	-	-	-	1.18	42.38	7.08	24.73	7.08	2.37	4.72	-	-	-	7.00	-	-	-	-	-	-	38.12	
Ashes, cottonseed hull,	39	7.66	-	-	-	-	32.80	13.44	21.86	15.53	6.26	8.00	-	-	-	7.22	12.47	-	7.31	-	-	-	10.01	
Ashes, cremation swill,	15	4.86	-	-	-	-	8.83	1.25	3.97	32.36	7.47	14.16	-	-	-	33.58	1.87	4.65	-	-	-	-	21.57	
Ashes, garbage,	3	3.01	-	-	-	-	6.01	3.72	5.13	10.21	7.16	8.77	-	-	-	15.65	20.22	1.16	9.22	4.57	10.85	4.75	28.42	
Ashes, hard pine,	1	.75	-	-	-	-	-	-	10.16	-	-	2.24	-	-	-	-	24.95	-	-	-	-	-	29.90	
Ashes, hay and straw,	1	.40	-	-	-	-	-	-	1.55	-	-	1.02	-	-	-	-	5.22	-	-	-	-	-	66.35	
Ashes, hemp,	1	none	-	-	-	-	-	-	2.48	-	-	1.74	-	-	-	60.47	-	-	-	-	-	-	3.14	
Ashes, jute waste,	1	.19	-	-	-	-	-	-	.51	-	-	.54	-	-	-	3.84	6.04	.39	7.60	-	-	.57	81.02	
Ashes, leather scrap,	3	5.94	-	-	-	.15	3.36	1.00	2.23	3.96	1.80	2.89	-	-	-	-	7.80	-	-	-	-	-	46.08	
Ashes, lime,	42	9.10	-	-	-	-	4.93	.16	1.77	1.68	.03	.70	-	-	-	-	44.58	1.30	-	-	-	-	7.27	
Ashes, log wood,	1	1.50	-	-	-	-	-	-	.08	-	-	2.30	-	-	-	3.90	-	-	-	-	-	-	9.70	

Ashes, magnolia,	1	1.58	-	-	-	-	2.56	-	-	.45	-	-	-	-	-	-
Ashes, peach-tree trimmings,	1	.54	-	-	-	-	4.92	-	-	2.44	-	-	-	-	-	-
Ashes, peat,	3	6.50	-	-	-	.46	.07	.33	1.62	.11	.72	-	-	7.53	18.74	-
Ashes, picker waste,	1	.28	-	-	-	-	-	-	-	-	1.18	-	-	-	-	-
Ashes, pine wood,	1	2.76	-	-	-	-	-	-	-	-	3.07	-	-	23.61	-	-
Ashes, pulp,	1	none	-	-	-	-	-	-	-	.12	-	-	-	67.72	-	-
Ashes, railroad ties,	1	4.70	-	-	-	-	-	.92	-	.56	-	-	-	2.51	-	-
Ashes, refuse from sawdust,	1	13.92	-	-	-	-	-	3.58	-	7.92	-	-	-	34.76	-	-
Ashes, roofing paper,	1	.06	-	-	-	-	-	.08	-	.65	-	-	-	5.65	12.90	11.17
Ashes, seaweed,	1	1.47	-	-	-	-	-	.92	-	.30	-	-	-	8.76	6.06	4.37
Ashes, soft coal and sawdust,	1	3.36	-	-	-	-	-	.73	-	.74	-	-	-	2.80	-	-
Ashes, soft and buckwheat coal,	1	.85	-	-	-	-	-	.45	-	.37	-	-	-	1.70	-	-
Ashes, spent tan bark,	5	4.84	-	-	-	2.87	.60	1.81	2.77	.13	1.36	-	-	31.11	3.39	1.78
Ashes, tan bark,	1	1.50	-	-	-	-	-	.52	-	.77	-	-	-	24.29	-	-
Ashes, walnut wood,	1	3.79	-	-	-	-	-	5.06	-	2.07	-	-	-	40.73	-	-
Ashes, wood and coal,	1	1.32	-	-	-	-	-	.44	-	1.15	-	-	-	2.39	-	-
Ashes, wood,	735	12.67	-	-	-	13.58	1.12	5.13	6.07	.06	1.51	-	-	32.44	3.31	7.43
Ashes, wool waste,	1	8.40	-	-	-	-	-	27.24	-	.26	-	-	-	2.88	-	-
Acetylene gas tank refuse,	2	30.07	-	-	-	-	-	-	-	-	-	-	-	42.65	-	8.17
Wood charcoal,	2	2.65	-	-	-	-	-	.40	-	.16	-	-	-	-	-	-
(b) Lime Compounds.																
Agricultural lime,	38	2.79	-	-	-	-	-	-	-	-	-	-	-	61.26	3.08	2.93
Bleachery refuse,	2	4.19	-	-	-	1.24	.35	.79	-	-	-	-	-	11.69	35.79	-

(b) *Lime Compounds.*

[illegible]

C. ASHES, LIME COMPOUNDS AND MARLS — *Concluded.*

[Figures equal percentages or pounds in 100.]

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.			Soluble Phos- phoric Acid.	Reverted Phos- phoric Acid.	Insoluble Phos- phoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.	
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.												
(b) Lime Compounds — Con.																								
Boiler cleanings,	1	3.44	-	-	-	.28	-	-	4.15	-	-	1.14	-	-	-	-	21.92	-	-	-	-	-	-	24.32
Burned lump lime,	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.63	-	-	-	-	-	-	1.33
Carbonate of lime,	4	.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52.33	-	-	40.75	-	-	-	.42
Carbonate of lime (coral),	2	19.76	-	-	-	.28	.14	.11	.13	.21	.16	.18	-	-	-	.32	38.18	.93	.62	-	43.39	-	-	9.49
Gas-house lime,	5	11.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48.19	8.30	-	19.66	-	-	-	8.99
Ground lime stone (unburned), . .	1	.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42.56	-	-	30.56	-	-	-	19.66
Gypsum,	3	8.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36.00	-	-	51.43	-	-	-	-
Lime waste from tannery,	2	.88	-	-	-	.65	-	-	-	-	-	-	-	-	-	-	54.78	-	-	-	-	-	-	2.83
Lime waste from sugar factory, . .	1	36.30	-	-	-	-	-	-	.22	-	-	2.25	-	-	-	-	27.51	-	-	-	-	-	-	.26
Lime waste from soda factory, . .	1	24.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.86	1.36	-	23.14	-	-	-	1.33
Lime sludge from glue factory, . .	1	37.20	-	-	-	.63	-	-	-	-	-	.15	-	-	-	-	19.62	-	-	-	14.51	-	-	-
Magnesia lime,	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47.55	32.75	-	1.35	-	-	-	-
Nova Scotia plaster (gypsum), . .	17	6.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.74	.75	-	44.87	-	-	-	5.79
Onondaga plaster, New York, gypsum, .	4	13.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.00	4.66	-	32.50	8.20	-	-	9.83
Oyster shell lime, partially burned, .	7	5.13	-	-	-	.17	-	-	-	-	-	.36	-	-	-	-	45.87	-	-	20.73	-	-	-	10.08

D. BY-PRODUCTS AND REFUSE SUBSTANCES.

[Figures equal percentages or pounds in 100.]

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.			Soluble Phos- phoric Acid.	Reverted Phos- phoric Acid.	Insoluble Phos- phoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.													
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
(a) Abattoir Products.																							
Ammoniate,	1	5.88	-	-	-	11.33	-	-	-	-	-	3.43	-	-	-	-	-	-	-	-	-	-	1.38
Blood and bone,	5	5.97	-	7.19	5.70	6.23	-	-	-	12.86	11.38	12.14	-	4.41	7.73	-	-	-	-	-	-	-	-
Bone dust,	1	5.06	-	-	-	3.06	-	-	-	-	-	17.80	-	7.24	10.56	-	-	-	-	-	-	-	-
Bone fiber,	1	5.38	-	-	-	4.61	-	-	-	-	-	12.44	-	6.76	5.68	-	-	-	-	-	-	-	-
Beef scrap,	1	7.12	-	-	-	7.46	-	-	-	-	-	9.42	-	3.10	6.32	-	-	-	-	-	-	-	-
Bone soup,	2	87.01	-	1.42	1.14	1.28	-	-	.01	1.26	.04	.65	-	-	-	-	-	-	-	-	-	-	-
Bone scrapings,	1	-	-	-	-	4.04	-	-	-	-	-	27.22	-	-	-	-	-	-	-	-	-	-	-
Concentrated tankage,	1	7.99	-	-	-	11.16	-	-	-	-	-	1.72	-	-	-	-	-	-	-	-	-	-	-
Condensed bone steam,	1	81.75	-	-	-	1.94	-	-	-	-	-	.07	-	-	-	-	-	-	-	-	-	-	-
Dried blood,	61	10.48	6.37	13.78	7.99	10.26	-	-	-	8.83	.03	2.69	-	-	-	-	-	-	-	-	-	-	.64
Dried soup from meat and bone,	1	14.80	8.40	-	-	9.97	-	-	-	-	-	.53	-	-	-	-	-	-	-	-	-	-	.26
Dried soup from rendering cattle feet,	1	10.80	7.50	-	-	14.47	-	-	-	-	-	.46	-	-	-	-	-	-	-	-	-	-	-
Fresh-cut bone,	1	24.98	-	-	-	3.00	-	-	-	-	-	16.85	-	5.26	11.59	-	-	-	-	-	-	-	-
Ground bone (raw),	17	6.12	-	6.32	2.19	3.82	-	-	-	27.40	13.94	22.75	-	7.43	15.32	-	-	-	-	-	-	-	-
Ground bone (steamed),	100	6.92	-	3.63	.97	2.99	-	-	-	31.37	23.22	24.93	-	9.25	15.68	-	-	-	-	-	-	-	-

D. BY-PRODUCTS AND REFUSE SUBSTANCES — Continued.

[Figures equal percentages or pounds in 100.]

FERTILIZER MATERIALS.	Analysis.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.			Soluble Phos- phoric Acid.	Reverted Phos- phoric Acid.	Insoluble Phos- phoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.	
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.												
(c) Sea Weeds — Con.																								
Irish or Carogeen moss (<i>Chondrus Crispus</i>),	3	76.13	-	.81	.34	.57	1.46	.66	1.02	.20	.10	.13	-	-	-	-	.49	.33	-	-	-	-	-	.09
Kelp or ribbon weed (<i>Laminaria Sacchar- inal</i>).	3	37.99	-	.22	.12	.17	.17	.14	.16	.06	.03	.05	-	-	-	-	.38	.17	-	-	-	-	-	.04
Rockweed (green),	1	68.50	23.70	-	-	.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockweed (dry),	2	13.73	35.75	1.45	1.07	1.26	4.89	1.56	3.22	2.75	.14	1.44	-	-	-	5.97	4.88	.96	1.22	-	.16	-	-	-
Round stalked rockweed (<i>Ascopyleum nodosum</i>).	3	77.26	-	.32	.18	.24	.75	.55	.64	.08	.08	.08	-	-	-	-	.48	.35	-	-	-	-	-	.03
Sea weed (decomposed),	1	78.93	-	-	-	.55	-	-	.15	-	-	.04	-	-	-	-	.24	-	-	-	-	-	-	13.97
(d) Vegetable Products.																								
Banana skins,	1	13.99	-	-	-	.24	-	-	5.46	-	-	1.80	-	-	-	-	-	-	-	-	-	-	-	-
Blue-green algae (<i>Lunghia Majusculas</i>), .	1	16.26	-	-	-	4.25	-	-	.79	-	-	.19	-	-	-	3.53	2.06	1.18	-	-	-	-	-	5.53
Brewers' grains (rotten),	1	78.77	-	-	-	.72	-	-	.04	-	-	.43	-	-	-	-	.26	.15	-	-	-	-	-	.59
Brewery, kiln dust from,	1	9.72	-	-	-	4.32	-	-	2.16	-	-	.96	-	-	-	-	.78	-	-	-	-	-	-	7.11
Broom corn seed,	1	7.40	-	-	-	1.51	-	-	.50	-	-	.57	-	-	-	-	-	-	-	-	-	-	-	-
Calico works, refuse from,	1	4.07	-	-	-	4.28	-	-	-	-	-	11.95	-	-	-	-	-	-	-	-	-	-	-	-
Castor bean pomace,	24	8.20	5.70	6.17	4.65	5.22	3.40	.64	1.21	2.26	1.57	2.07	-	-	-	-	.92	.29	.82	-	-	-	-	1.75
Cassava waste,	1	9.03	-	-	-	.33	-	-	.28	-	-	.06	-	-	-	-	.61	-	-	-	-	-	-	-

D. BY-PRODUCTS AND REFUSE SUBSTANCES — *Concluded.*

[Figures equal percentages or pounds in 100.]

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.			Soluble Phos- phoric Acid.	Reverted Phos- phoric Acid.	Insoluble Phos- phoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.	
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.												
(e) Wool Products — Con.																								
	2	41.37	—	1.09	.93	1.01	13.38	10.15	11.76	.32	.10	.21	—	—	—	—	—	—	—	—	—	—	—	—
Wool washings and concentrated paste,	5	39.80	51.18	.44	.31	.38	.89	.41	.63	.18	.09	.12	—	—	—	—	1.29	—	1.66	—	—	—	—	47.02
Wool washing, refuse from,	1	6.95	7.54	—	—	12.88	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.63	
Wool, raw, .	4	3.51	—	8.20	1.52	3.60	3.52	.82	2.27	.52	trace	.20	—	—	—	—	—	—	—	—	—	—	30.40	
Wool scouring, dried refuse from,																								
(f) Miscellaneous Substances.																								
Dredging from Cape Cod,	1	18.99	—	—	—	.99	—	—	.13	—	—	.07	—	—	—	—	—	—	2.06	—	—	.54	—	
Egg shells, ground,	1	1.15	73.30	—	—	1.19	—	—	.14	—	—	.38	—	—	—	—	47.47	—	—	—	—	—	.10	
Feldspar,	2	.11	—	—	—	—	11.56	7.32	9.44	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Fleshings from tannery,	2	33.20	—	7.55	.85	4.20	—	—	—	.31	.12	.22	—	—	—	—	—	—	—	—	—	—	8.48	
Garbage tankage,	1	2.12	—	—	—	5.95	—	—	—	—	—	6.06	—	—	—	—	—	—	—	—	—	—	—	
Glass factory, refuse from,	1	16.48	—	—	—	—	—	—	19.50	—	—	—	—	—	—	6.12	—	—	—	—	—	—	—	
Glue refuse,	1	28.03	11.67	—	—	1.90	—	—	—	—	—	.37	—	—	—	—	—	—	—	—	—	—	—	
Granite,	3	.30	—	—	—	—	3.50	1.33	2.11	—	—	trace	—	—	—	—	—	.11	19.53	—	—	—	70.25	
Ivory dust,	1	11.50	52.63	—	—	6.64	—	—	—	—	—	24.56	.97	17.97	5.62	—	—	—	—	—	—	—	—	
Lactate factory, waste from,	1	34.11	—	—	—	.68	—	—	—	—	—	.67	—	—	—	—	22.59	—	—	—	—	—	6.92	

E. ANIMAL EXCREMENTS.

[Figures equal percentages or pounds in 100.]

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOS- PHORIC ACID.			Soluble Phos- phoric Acid.	Reverted Phos- phoric Acid.	Insoluble Phos- phoric Acid.	Sodium Oxide.	Calcium Oxide (lime).	Magnesium Oxide.	Ferric and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Barnyard manure,	47	72.71	8.29	1.19	.18	.46	.92	.25	.55	.74	.10	.35	-	-	-	-	4.51	-	-	-	-	-	5.74
Compost,	1	1.70	-	-	-	.79	-	-	.97	-	-	.56	-	-	-	-	-	-	-	-	-	-	-
Dog manure,	1	6.50	-	-	-	1.91	-	-	.30	-	-	9.95	-	-	-	-	-	-	-	-	-	-	-
Drainage from manure heap,	1	93.20	3.66	-	-	.98	-	-	.88	-	-	.24	-	-	-	-	-	-	-	-	-	-	-
Duck manure (fresh),	1	61.62	-	-	-	1.12	-	-	.49	-	-	1.44	-	-	-	-	1.12	-	-	-	-	-	13.37
Goose manure (fresh),	2	57.99	-	1.12	.21	.67	.81	.51	.66	.95	.53	.74	-	-	-	-	.26	-	-	-	-	-	11.10
Guinea pig manure,	1	8.35	-	-	-	1.74	-	-	1.66	-	-	.55	-	-	-	-	.39	-	-	-	-	-	3.87
Hen manure (fresh),	8	65.14	-	2.30	1.07	1.56	.63	.42	.44	2.07	.50	1.09	-	-	-	-	1.62	-	-	-	-	-	10.20
Hen manure (dry),	1	5.66	-	-	-	2.08	-	-	1.01	-	-	1.68	-	-	-	-	2.72	-	-	-	-	-	-
Hen house refuse,	2	7.37	-	-	-	.71	-	-	1.03	-	-	1.02	-	-	-	-	-	-	-	-	-	-	71.07
Horse manure,	2	44.44	-	.74	.33	.54	2.82	.69	1.75	1.46	.21	.84	-	-	-	-	-	-	-	-	-	-	-
Liquid manure,	1	96.56	-	-	-	.56	-	-	.02	-	-	.01	-	-	-	-	-	-	-	-	-	-	-
Pigeon manure (fresh),	2	22.24	16.00	-	-	4.19	-	-	1.41	-	-	2.24	-	-	-	-	1.49	-	-	-	-	-	13.76
Poudrette, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	-	5.74	-	-	-	-	-	-	-	-	-	-	4.65
Sheep manure, dry,	15	7.77	-	-	-	2.13	-	-	2.08	-	-	1.38	-	-	-	-	2.91	-	-	-	-	-	22.90

F. ANALYSES OF INSECTICIDES.

[Figures equal percentages or pounds in 100.]

	Analyses.	Moisture.	Arsenious Oxide	Arsenious Oxide	Copper Oxide.	Arsenious Oxide	Water Soluble	Lead Oxide.	Zinc Oxide.	Barium Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulfur.	Sulfuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxide.	Insoluble Matter in Hydrochloric Acid.
Barium arsenate (white arsenoid),	1	2.35	31.90	-	-	-	-	.96	-	48.31	-	3.19	-	-	-	-	-	-	-	-
Copper arsenite,	2	5.21	51.52	36.82	-	-	8.08	-	-	-	-	-	-	-	-	-	-	-	-	.09
Lead arsenate (dry neutral),	3	2.49	-	-	-	25.92	.25	63.19	-	-	-	-	-	-	-	-	-	-	-	.22
Lead arsenate (dry acid),	2	.50	-	-	-	30.21	.09	64.50	-	-	-	-	-	-	-	-	-	-	-	.04
Lead arsenate (waste from),	8	44.58	-	-	-	15.58	-	36.21	-	-	6.76	-	-	-	-	-	-	-	-	.06
Laurel green,	1	7.64	7.34	13.50	-	-	-	-	-	-	-	-	-	-	-	-	26.31	-	-	-
Lime arsenite,	1	.80	76.31	-	-	-	40.88	-	-	-	-	-	-	-	-	-	21.63	-	-	.02
Nicotina,	1	10.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Paris green,	27	.85	58.44	30.96	-	-	4.41	-	-	-	-	-	-	-	-	-	-	-	-	.21
Paris green (aceto copper arsenite,)	2	1.12	56.65	31.34	-	-	1.46	-	-	-	11.95	-	-	-	-	-	-	-	-	.03
Paris green (collected during 1901),	14	.81	57.73	29.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrox,	1	58.09	-	4.21	6.79	-	-	16.35	-	-	-	-	-	-	-	-	5.27	-	-	-
Tobacco liquor,	1	37.71	-	-	-	-	-	-	-	-	-	-	2.12	-	-	-	3.07	6.55	.23	-
Tobacco liquor,	1	40.89	-	-	-	-	-	-	-	-	-	-	.53	-	-	-	1.47	16.34	.01	-

TABLE VI.—COMPILATION OF ANALYSES OF FRUITS
AND GARDEN CROPS.

H. D. HASKINS.

- A. Analyses of fruits.
- B. Analyses of garden crops.
- C. Relative proportions of phosphoric acid, potassium oxide and nitrogen found in fruits and garden crops.

The figures in A and B are in parts per 1,000. To convert into percentages or pounds in 100, move the decimal point one place to the left.

Some of the following analyses were taken from the compilation of E. Wolff. Those marked with an asterisk (*) were made at the laboratory of the Massachusetts Agricultural Experiment Station.

The tables will be found suggestive when one is preparing fertilizer formulas for various fruit and garden crops. One has also to consider, however, in making such fertilizer mixtures, the influence of cultivation and crop rotation as well as the plant food in the soil.

Members of the clover family are not dependent wholly upon supplied nitrogen, they having the power, after a vigorous start, to acquire atmospheric nitrogen when plenty of potash phosphoric acid and lime are supplied. An excess of phosphoric acid may be used in formulas without danger of loss from leaching. The same is true, to a certain extent, in case of potash, although this element is more often found in a water-soluble form in soils than is phosphoric acid. The well-known system of crop fertilization advocated originally by Wagner is based upon the necessity of an abundant supply of potash and phosphoric acid in the soil, while the nitrogen is added in such limited amounts and at such times as will provide for the maximum growth of the crop and the minimum loss through leaching.

A. ANALYSES OF FRUITS.
Fertilizer Constituents of Fruits.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Ericaceæ: —										
*Cranberries,	996	—	1.8	.9	.1	.3	.1	.3	—	—
*Cranberries,	894	.8	—	1.0	—	.2	.1	.3	—	—
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	—
*Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	—	—
Cherries,	825	—	3.9	2.0	.1	.3	.2	.6	.2	.1
*Peaches,	884	—	3.4	2.5	—	.1	.2	.5	—	—
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	—

Fertilizer Constituents of Fruits — Concluded.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
<i>Rosaceæ — Con.</i>										
Plums,	838	—	2.9	1.7	—	.3	.2	.4	.1	—
Strawberries,	902	—	3.3	.7	.9	.5	—	.5	.1	.1
*Strawberries,	—	—	5.2	2.6	.2	.7	.4	1.0	—	—
*Strawberry vines,	—	—	33.4	3.5	4.5	12.2	1.3	4.8	—	—
<i>Saxifragaceæ: —</i>										
*Currants, red,	871	—	4.1	1.9	.2	.8	.3	.9	—	—
*Currants, white,	—	—	5.9	3.1	.2	1.0	.3	1.1	—	—
Gooseberries,	903	—	3.3	1.3	.3	.4	.2	.7	.2	—
<i>Viticeæ: —</i>										
Grapes,	830	1.7	8.8	5.0	.1	.7	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

B. ANALYSES OF GARDEN CROPS.
Fertilizer Constituents of Garden Crops.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Chenopodiaceæ: —										
*Beets, red,	877	2.4	11.3	4.4	.9	.5	.3	.9	—	—
Beets, sugar,	750	1.4	6.0	2.3	1.4	.6	.5	.8	.2	.2
*Beets, sugar,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	—
Beets, sugar, leaves,	800	3.0	15.0	3.0	3.0	1.5	1.1	.7	.5	1.0
Beets, sugar, seed,	146	—	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9
Beets, sugar, tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Mangolds,	900	1.2	6.5	2.8	1.5	.3	.4	.6	.3	.9
*Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	—	—

Fertilizer Constituents of Garden Crops — Continued.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
<i>Chenopodiaceæ — Con.</i>										
Mangold leaves,	905	3.0	14.6	5.0	2.8	1.6	1.4	.8	.8	2.3
Spinach,	903	4.9	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
*Spinach,	922	3.4	9.6	9.6	2.1	.6	.5	.5	—	—
<i>Compositæ: —</i>										
Artichoke,	811	—	10.1	2.4	.7	1.0	.4	3.9	.5	.2
*Artichoke, Jerusalem,	775	4.6	—	4.8	—	—	—	1.7	—	—
Lettuce, common,	940	—	8.1	3.7	.8	.5	.2	.7	.3	.4
Lettuce, head,	943	2.2	10.3	3.9	.8	1.5	.6	1.0	1.1	.8
*Lettuce, head,	970	1.2	—	2.3	.2	.3	.1	.3	—	—
Lettuce, Roman,	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4

Fertilizer Constituents of Garden Crops — Continued.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Cucurbitaceæ:—										
Cucumbers,	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins,	900	1.1	4.4	.9	.9	.3	.2	1.6	.1	—
Gramineæ:—										
Barley, grains,	108	19.2	—	4.8	—	—	—	7.9	—	—
Buckwheat, grain,	134	17.3	—	3.0	—	—	—	6.9	—	—
Corn, kernels,	144	16.0	12.8	3.7	.1	.3	1.9	5.7	.1	.2
*Corn, kernels,	100	18.2	—	4.0	.3	.3	2.1	7.0	—	—
*Corn, whole ears,	90	14.1	—	4.7	.6	.2	1.8	5.7	—	—
*Corn, stover,	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	—	—
Corn, whole plant, green,	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5

*Corn, whole plant, green,	786	4.1	—	3.8	.5	1.5	.9	1.5	—	—
Hay, English,	140	12.6	—	16.1	—	3.2	—	3.2	—	—
Millet seed,	140	18.5	29.5	3.3	.4	6.5	2.8	.1	.1	.1
Oats, grain,	143	17.6	27.4	4.8	.4	7.4	1.9	.5	.3	.3
Rye, grain,	87	18.1	—	5.8	—	8.6	—	—	—	—
Wheat, grain,	144	20.0	—	5.2	—	8.0	—	—	—	—
Leguminosæ: —										
Alfalfa hay,	68	24.7	—	17.9	—	6.1	—	—	—	—
Bean straw,	160	—	40.2	12.8	3.2	3.9	2.5	1.7	3.1	3.1
Clover, hay,	153	19.7	—	18.7	—	5.5	—	—	—	—
*Cow pea, green,	788	2.9	—	3.1	.6	1.0	1.0	—	—	—
Garden beans, seed,	150	39.8	27.4	12.1	.4	9.7	2.1	1.1	.3	.3
Hay of peas cut green,	167	22.9	62.4	23.2	2.3	6.8	6.3	5.1	2.0	2.0
*Leaves and stems of velvet beans,	58.8	28.6	—	—	—	—	—	—	—	—
Peas, straw,	160	10.4	43.1	9.9	1.8	3.5	3.5	2.7	2.3	2.3
Peas, seed,	143	36.5	27.5	12.5	.2	10.0	1.9	.8	.4	.4

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Leguminosæ:—										
*Small pea, dry (<i>Lathyrus Sylvestris</i>), .	90	38.5	—	25.7	4.7	17.9	5.0	9.0	—	—
Soy bean, seed,	100	53.4	28.3	12.6	.3	1.7	2.5	10.4	.8	.1
*Velvet beans, kernel,	111.6	31.1	—	13.2	—	—	—	7.7	—	—
*Velvet beans, with pod,	115.2	19.6	—	13.1	—	—	—	8.4	—	—
Liliacæ:—										
*Asparagus,	942	3.3	—	3.29	—	—	—	1.08	—	—
Asparagus,	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3
*Asparagus roots, ¹	81.7	16.2	58.8	21.6	1.8	2.8	1.4	4.7	4.0	—
Onions,	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
*Onions,	892	—	4.9	1.8	.1	.4	.2	.7	—	—
Solanacæ:—										
Potatoes,	750	3.4	9.5	4.0	.3	.3	.5	1.6	.6	.3
*Potatoes,	798	2.1	9.9	2.9	.1	.1	.2	.7	—	—

Potato tops, nearly ripe,	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe,	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
Tobacco leaves,	180	24.5	150.7	50.9	4.5	50.7	10.4	6.6	8.5	9.4
*Tomatoes,	940	1.7	—	3.6	—	.3	.2	.4	—	—
*Tobacco, whole leaf,	103.1	24.3	—	57.9	24.7	45.8	13.8	4.3	16.3	1.59
Tobacco stalks,	180	16.4	74.7	38.2	6.6	12.4	.5	9.2	2.2	2.4
*Tobacco stems,	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	—	—
Umbelliferae: —										
Carrots,	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.2	.4
*Carrots,	898	1.5	9.2	5.1	.6	.7	.2	.9	—	—
Carrot tops,	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry,	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	—	—
Celery,	841	2.4	17.6	7.6	—	2.3	1.0	2.2	1.0	2.8
Parsnips,	793	5.4	10.0	5.4	.2	1.1	.6	1.9	.5	.4
*Parsnips,	803	2.2	—	6.2	.1	.9	.5	1.9	—	—

¹ Twenty-four analyses.

C. RELATIVE PROPORTIONS OF PHOSPHORIC ACID, POTASSIUM OXIDE
AND NITROGEN IN FRUITS AND GARDEN CROPS.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
FRUITS.			
Ericaceæ: —			
*Cranberries,	1	3.0	—
*Cranberries,	1	3.33	2.66
Rosaceæ: —			
Apples,	1	2.7	2.0
*Apples,	1	1.9	1.3
Cherries,	1	3.3	—
*Peaches,	1	1.3	—
Pears,	1	3.6	1.2
Plums,	1	4.3	—
Strawberries,	1	1.4	—
*Strawberries,	1	2.6	—
*Strawberry vines,	1	.7	—
Saxifragaceæ: —			
*Currants, red,	1	2.1	—
*Currants, white,	1	2.8	—
Gooseberries,	1	1.9	—
Viticeæ: —			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7
GARDEN CROPS.			
Chenopodiaceæ: —			
*Beets, red,	1	4.1	3.3
Beets, sugar,	1	2.88	1.75

C. RELATIVE PROPORTIONS OF PHOSPHORIC ACID, ETC., IN FRUITS
AND GARDEN CROPS — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Chenopodiaceæ — <i>Con.</i>			
*Beets, sugar,	1	4.8	2.2
Beets, sugar, leaves,	1	4.28	4.28
Beets, sugar, tops,	1	2.3	1.7
Beets, sugar, seed,	1	1.5	—
Mangolds,	1	4.66	2.0
*Mangolds,	1	4.2	2.1
Mangold leaves,	1	6.25	3.75
Spinach,	1	1.7	3.06
*Spinach,	1	19.2	6.8
Compositæ: —			
Artichoke,	1	.63	—
*Artichoke, Jerusalem,	1	2.8	2.7
Lettuce, common,	1	5.3	—
Lettuce, head,	1	3.9	2.2
*Lettuce, head,	1	7.7	4.0
Lettuce, Roman,	1	2.3	1.8
Convolvulaceæ: —			
Potato, sweet,	1	4.6	3.0
Cruciferæ: —			
Cauliflower,	1	2.3	2.5
Cabbage, leaves,	1	4.1	1.7
Cabbage, Savoy,	1	1.9	2.5
Cabbage, white,	1	4.1	1.7
*Cabbage, white,	1	11.0	7.6

C. RELATIVE PROPORTIONS OF PHOSPHORIC ACID, ETC., IN FRUITS
AND GARDEN CROPS — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Cruciferae — <i>Con.</i>			
Kohlrabi,	1	1.6	1.8
Radishes,	1	3.2	3.8
Radish, horse,	1	3.9	2.2
*Ruta-bagas,	1	4.1	1.6
Turnips, white,	1	3.6	2.3
*Turnips, white,	1	3.9	1.8
Turnips, white, leaves,	1	3.1	3.3
Cucurbitaceae: —			
Cucumbers,	1	2.0	1.3
Pumpkins,	1	.56	.69
Gramineae: —			
Barley, grain,	1	.61	2.43
Buckwheat, grain,	1	.43	2.51
Corn, whole plant, green,	1	3.7	1.9
*Corn, whole plant, green,	1	2.2	2.8
Corn, kernels,	1	.6	2.8
*Corn, kernels,	1	.6	2.6
*Corn, stover,	1	4.4	3.7
*Corn, whole ears,	1	.8	2.5
Hay, English,	1	5.03	3.93
Millet, seed,	1	.51	2.84
Oats, grain,	1	.65	2.38
Rye, grain,	1	.67	2.10
Wheat, grain,	1	.65	2.50

C. RELATIVE PROPORTIONS OF PHOSPHORIC ACID, ETC., IN FRUITS
AND GARDEN CROPS — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Leguminosæ: —			
Alfalfa, hay,	1	2.93	4.05
Bean straw,	1	3.3	—
Clover, hay,	1	3.4	3.58
*Cow pea, green (<i>Dolichos</i>), . .	1	3.1	2.9
Garden beans, seed,	1	1.2	4.0
Hay of peas, cut green,	1	3.4	3.4
Peas, seed,	1	1.2	3.65
Pea straw,	1	2.8	4.0
Soy bean seed,	1	1.21	5.12
*Small pea, dry (<i>Lathyrus sylvestris</i>),	1	3.4	4.2
*Velvet beans, kernel,	1	1.7	4.0
*Velvet beans, with pod,	1	1.56	2.3
Liliacæ: —			
*Asparagus,	1	3.05	3.06
Asparagus,	1	1.3	3.6
*Asparagus roots, ¹	1	4.60	3.45
Onions,	1	1.9	2.1
*Onions,	1	2.6	—
Solanacæ: —			
Potatoes,	1	2.5	2.1
*Potatoes,	1	4.1	3.0
Potato tops, nearly ripe,	1	2.7	3.1
Potato tops, unripe,	1	3.7	5.3

¹ Twenty-four analyses.

C. RELATIVE PROPORTIONS OF PHOSPHORIC ACID, ETC., IN FRUITS
AND GARDEN CROPS — *Concluded.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
<i>Solanaceæ — Con.</i>			
Tobacco leaves,	1	7.71	3.71
*Tobacco, whole leaf,	1	13.46	5.65
Tobacco stalks,	1	4.15	1.78
*Tobacco stems,	1	10.7	3.8
*Tomatoes,	1	8.7	4.5
<i>Umbelliferæ: —</i>			
Carrots,	1	2.7	2.0
*Carrots,	1	5.7	1.7
Carrot tops,	1	2.9	5.1
Carrot tops, dry,	1	8.0	5.1
Celery,	1	3.5	1.1
Parsnips,	1	2.8	2.8
*Parsnips,	1	3.3	1.2

COMPOSITION OF SOME MASSACHUSETTS SOILS.

BY J. B. LINDSEY.

In the year 1892 samples of typical soils were taken from different parts of the State under the general supervision of Prof. William P. Brooks. Prof. Benjamin K. Emerson, the geologist of Amherst College, advised as to the most suitable location to secure some of the soils, in order that they might be representative. The soils were carefully analyzed under the direct supervision of the late Prof. C. A. Goessmann, and the completed results of each soil are here presented for the first time.

DESCRIPTION OF TYPES.

- Soil No. 1.* — Ten inches surface soil taken on the grounds of the Massachusetts agricultural experiment station, north of Hatch barn.
- Soil No. 2.* — Ten inches surface soil taken on Agawam Plains, not cultivated for ten years.
- Soil No. 3.* — Twelve inches surface soil taken from hill pasture in Agawam. The soil known as Agawam red sandstone.
- Soil No. 4.* — Granite till from Dedham, locality of Fox Hill; 12 inches surface soil.
- Soil No. 5.* — Cranberry bog from Colony Stock Farm; 6 inches surface soil.
- Soil No. 6.* — Diked Salt Marsh, Marshfield; tide shut off twenty years ago; soil cultivated.
- Soil No. 7.* — Soil of alluvial formation from Hadley meadows; overflowed in 1862 and 1872, and a deposit of sand was left which injured it materially.
- Soil No. 8.* — Virgin soil, taken from South River salt marsh, Marshfield, Mass.
- Soil No. 9.* — Natural fresh-water meadow from Sudbury, Mass.; very wet.
- Soil No. 10.* — Gneiss till from Shutesbury, Mass.; very barren.
- Soil No. 11.* — Mica schist from Deerfield, Mass.; taken from base of hill. Virgin soil, good pasture land, never cultivated.
- Soil No. 12.* — Limestone till from Pittsfield, Mass.
- Soil No. 13.* — Copperas rock from Hubbardston. Virgin soil, very strong.

Analysis of Types of Massachusetts Soils.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.
Coarse materials (.5 mm.),	1.42	14.48	45.81	23.63	—	6.13	.05	—	—	26.26	14.92	18.03	44.36
Fine earth,	98.58	85.52	54.19	76.37	100.00	93.87	99.95	100.00	100.00	73.74	85.08	81.97	55.64
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ANALYSIS OF FINE EARTH.													
Insoluble matter,	80.38	86.68	73.89	76.48	9.25	72.45	82.42	78.31	9.49	82.68	77.83	81.05	70.39
Soluble silica,	2.41	1.73	7.57	3.88	—	1.15	1.78	2.11	.26	1.20	1.82	.78	.92
Potash (K ₂ O), . . . . .	.38	.18	.30	.19	.16	.24	.22	.33	.53	.13	.40	.25	.46
Soda (Na ₂ O), . . . . .	.29	.38	.46	.42	.34	.19	.21	1.63	1.78	.38	1.56	.06	.95
Lime (CaO), . . . . .	.70	.68	.47	.41	.01	.68	.99	.36	1.71	.92	1.15	1.88	.80
Magnesia (MgO), . . . . .	.26	.81	.90	.49	—	.72	.83	.19	.66	.19	.79	.84	.22
Manganese oxide (Mn ₃ O ₄), . . . . .	.08	.17	.13	.09	—	.05	.07	.06	.09	.06	.07	.07	.04
Ferric oxide (Fe ₂ O ₃),	3.78	3.49	4.59	3.86	39 {	4.47	5.09	3.54	1.71	3.79	5.93	5.39	12.26
Alumina (Al ₂ O ₃),	6.22	4.27	6.64	4.69	.04	5.37	3.15	2.57	2.09	3.01	5.86	4.32	4.98
Phosphoric acid (P ₂ O ₅), . . . . .	.31	.10	.22	.06	.04	.24	.32	.13	.20	.20	.29	.29	.36
Sulfur trioxide (SO ₃), . . . . .	.15	.12	.12	.21	.38	.64	.27	.33	.71	.03	.05	.08	.05
Volatile matter,	4.88	2.08	4.37	9.81	89.76	14.42	3.83	9.89	80.13	6.89	4.45	4.92	8.72
Total,	99.80	100.69	99.66	100.59	100.33	100.62	99.28	99.45	99.36	99.48	100.20	100.03	99.85
Humus,	1.72	.46	.64	1.89	41.23	6.56	1.97	1.30	26.86	1.80	1.05	.87	1.46
Ash, . . . . .	.406	.026	.199	.249	1.90	.443	.275	.22	.56	.275	.28	.23	.34
Phosphoric acid, . . . . .	.079	.012	.032	.086	.027	.093	.145	.026	.11	.036	.053	.029	.026
Silica, . . . . .	.107	.006	.084	.12	—	.228	.320	.144	.28	.124	.11	.12	.17
Nitrogen, . . . . .	.20	.07	.09	.30	.27	.50	.11	.28	.43	.18	.12	.18	.155
Hygroscopic moisture,	5.38	3.69	10.69	7.40	26.29	14.85	3.81	20.66	36.78	5.200	4.25	8.88	14.54

According to Hilgard ¹ “ Virgin soils with high plant food percentages are always productive, provided, only, that extreme physical characters do not interfere with normal plant growth.” By high plant food percentages is meant 1 per cent. of acid soluble potash, 1 of lime, the same or less of magnesia and .15 per cent. of phosphoric acid. In case there is a low percentage of one of the above elements, it is an indication that this will be the first to fail, and will have to be supplied in the form of farm-yard manures or chemical fertilizers. The total percentage of nitrogen in the soil is of less importance than the nitrogen percentage in the humus, of which there should be at least 4 per cent. to insure satisfactory production.

It will be seen that none of the above soils could be classed as highly productive, yet by comparing the analyses with the standards for average soils as given further on, it will be seen that, in so far as their chemical analysis is concerned, most of them would be capable of producing satisfactory crops.

MISCELLANEOUS SOIL ANALYSES.

From time to time during the last ten or fifteen years the station has had occasion to examine soils sent from different sections of the State. The following tabulation shows the percentages of the more important fertilizer constituents which they contained. The data concerning the history of each soil are not at present available. From our present knowledge of the value of chemical analysis in determining soil fertility it is doubtful if such data would have proved particularly helpful, so much depending upon the physical character of the soil and subsoil, drainage and the character of the crops to be grown. This matter is briefly referred to further on. In general it may be said that the soils were taken from the cultivated fields of Massachusetts farms.

¹ Soils, by E. W. Hilgard, p. 343.

Table of Miscellaneous Soil Analyses (Per Cent.).¹

SOURCE.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Abington (garden?),	-	.85	.78	.44	-
Amesbury (reclaimed marsh),	6.21	1.41	.24	.36	-
Amherst (Massachusetts Agricultural College, productive),	-	.23	.26	.112	.06
Amherst (Massachusetts Agricultural College, unproductive).	-	.23	.16	.114	.07
Amherst (Massachusetts Agricultural College, experiment station).	-	.20	.16	.253	1.64
Amherst (Massachusetts Agricultural College, south acre),	-	.16	.13	.271	1.33
Amherst,	-	.48	.11	.36	.54
Amherst,	-	.18	.24	.17	.34
Amherst,	-	.08	.15	.07	.24
Amherst,	-	.11	.20	.15	.24
Amherst,	7.38	.21	.10	.21	.17
Amherst,	-	.16	.11	.28	1.04
Amherst,	-	.22	.07	.29	.73
Amherst,	-	.24	.11	.23	.67
Arlington (average of 3 samples),	-	.14	.15	.23	.80
Athol,	8.79	.27	.13	.11	.23
Barre (average of 3 samples),	-	.20	.25	.29	.65
Belmont,	8.57	.27	.21	.15	.12
Berlin,	-	.26	.14	.30	.46
Bernardston,	-	.12	.25	.20	.95
Bernardston,	-	.08	.15	.11	.15
Beverly,	-	.37	.30	.56	.56
Beverly,	-	.02	.22	.56	.50
Bisbees,	-	.21	.13	.25	.32
Boston,	6.02	.16	.205	.401	trace
Boston,	-	.35	.387	.26	1.17
Boston,	-	.13	.04	.09	.11
Boston,	-	.25	.26	.19	.13
Boston,	-	.11	.04	.11	.16
Boston,	4.25	.11	.04	.07	.55
Boston,	6.69	.20	.06	.01	.33
Boston,	6.04	.14	.06	.07	.21
Boston (near seacoast),	8.53	.47	.17	1.02	1.08

¹ Analyses made by H. D. Haskins and assistants.

Table of Miscellaneous Soil Analyses (Per Cent.) — Continued.

SOURCE.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Brockton (greenhouse?),	—	.42	.19	.11	.69
Brookfield,	—	.47	.36	.29	.20
Brookline (greenhouse?),	—	.93	.23	.21	1.42
Brookline (greenhouse?),	—	.51	.07	.25	1.48
Cambridge,	—	.18	.29	.18	.77
Canton,	—	.30	.19	.23	.78
Clinton,	—	.22	.13	.15	1.52
Clinton,	—	.22	.24	.81	.65
Concord,	9.88	.48	.21	—	trace
Concord (asparagus),	4.30	.13	.24	.09	.22
Conway,	—	.24	.07	.17	—
Conway,	—	.44	.09	.21	—
East Holliston,	—	.19	.14	.14	1.00
East Whately,	—	.14	.25	.24	.16
East Whately,	—	.11	.34	.18	.19
East Whately,	—	.19	.09	.18	.10
East Whately,	—	.12	.32	.49	.69
East Whately,	—	.08	.18	.53	.85
Florence (tobacco),	2.24	.81	.98	—	1.79
Florence (tobacco),	—	.96	.37	—	1.12
Foxborough,	9.47	.28	.08	.10	.63
Foxborough (average of 7 samples),	—	.21	.25	.16	1.19
Framingham,	—	.17	.34	.23	.56
Framingham,	—	.13	.13	.13	.24
Gloucester (low and swampy; reclaimed),	—	.86	.60	.74	1.00
Greenfield,	—	2.42	.30	.30	3.57
Hadley,	—	.15	.49	.24	.49
Hadley (mill pond basin),	—	.17	.08	.56	.82
Halifax (average of 6 samples),	12.18	.28	.03	.09	.26
Halifax (average of 2 samples),	—	.66	.31	.22	2.88
Halifax,	—	.10	.09	.26	.75
Hampden,	—	.20	.23	.13	.39
Hampden,	—	.41	.30	.08	.46
Harding,	—	.14	trace	.12	.30

Table of Miscellaneous Soil Analyses (Per Cent.) — Continued.

SOURCE.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Harding,	—	.12	trace	.11	.41
Harding,	—	.17	.04	.13	.24
Harding,	—	.14	trace	.17	.33
Haverhill,	—	.17	.45	.20	1.30
Haverhill (meadow, 3½ feet),	72.60	1.61	.09	.12	1.01
Haverhill (bank of river),	—	.51	.21	.13	.32
Holliston,	—	.20	.22	.25	1.00
Hubbardston,	—	.26	.12	.39	1.88
Lenox,	—	.07	.39	.28	1.41
Lenox,	9.18	.29	.23	.32	.10
Lenox,	—	.28	.34	.33	.85
Lenox,	—	.30	.17	.26	1.20
Lynn,	—	.39	.40	.32	1.51
Longmeadow,	—	.34	.20	.21	.54
Malden (garden soil),	12.57	.64	—	.49	.79
Mansfield (average of 3 samples),	—	.16	.15	.13	1.28
Mattapoissett,	—	.19	.20	.11	.73
Merrick,	—	.13	.35	.29	.79
Monson,	8.46	.24	.03	.21	.10
Montague (corn experiment plat),	—	.16	.13	.37	1.41
Newbury,	—	.26	trace	.16	.15
Newbury,	—	.28	.13	.15	.29
Newbury,	—	.28	.16	.23	.17
Newbury,	—	.28	.29	.15	.11
Newbury,	—	.29	.17	.15	.15
Newton,	—	.18	.01	.23	.59
Newton,	—	.18	.01	.23	.59
Newton,	—	.23	.07	.13	.76
Newton,	—	.22	.01	.14	.42
Newton,	—	.26	.08	.14	.82
Newton,	—	.22	.01	.14	.42
Newton,	—	.38	.23	.22	.85
Newton,	—	.10	.15	.22	1.19
Newton Highlands,	7.42	.31	.18	.16	—

Table of Miscellaneous Soil Analyses (Per Cent.) — Continued.

SOURCE.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Newton Highlands,	—	.34	.07	.50	.65
New Bedford (average of 6 samples),	—	.24	.14	.25	.53
Northampton (average of 3 samples),	—	.14	.19	.39	1.00
North Adams,	—	.60	.36	.89	2.41
North Adams,	—	.23	.14	.62	.40
North Adams,	—	.25	.10	.55	.30
North Eastham (asparagus farm),	—	.22	.05	.07	.58
North Easton,	—	.12	.09	.21	—
North Easton,	—	.19	.24	.20	—
North Weymouth,	—	.35	.10	.34	.67
North Weymouth,	—	.32	.32	.25	.71
Norton,	—	.18	.05	.09	.75
Norton (average of 3 samples),	—	.14	.15	.09	.84
Orange,	—	.20	.11	.28	.38
Orange,	—	.44	.20	.20	.49
Plymouth,	—	.15	.10	.18	.50
Rutland (sanatorium),	—	.20	.16	.25	.09
Seituate,	—	.33	.13	.10	.16
South Carver,	—	.06	.08	.19	.23
South Carver,	—	.10	.29	.59	.48
South Carver,	—	.11	.31	.39	.27
South Framingham (average of 6 samples),	6.89	.22	.14	.19	.47
Springfield,	—	.16	.18	.22	.57
Springfield,	—	.15	.16	.16	.55
Springfield,	—	.39	.14	.48	1.32
Sunderland,	14.09	.64	.70	.49	.54
Swift River,	—	.23	.09	.23	.17
Taunton,	—	.34	.23	.22	trace
Tewksbury (average of 2 samples),	6.93	.36	—	.29	.64
Truro,	—	.19	.24	.27	.81
Upton (carnation soil),	—	.41	.44	.20	.64
Upton (carnation soil),	—	.23	.69	.23	.83
Upton (carnation soil),	—	.50	.81	.46	.60
Waltham (greenhouse?),	—	.76	.40	.47	.83

Table of Miscellaneous Soil Analyses (Per Cent.) — Concluded.

SOURCE.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Webster,	1.25	—	.03	—	—
Wellesley,	—	.28	.66	.28	1.77
Westfield,	—	.29	.25	.31	.95
Westminster,	—	.32	.13	.30	.28
West Newton,	—	.14	.25	.16	1.14
West Springfield (average 14 samples),	—	.25	.51	.36	.97
Weymouth,	5.69	.24	.11	.24	.34
Whately,	—	.12	.02	.58	1.07
Whately,	—	.13	.20	.36	.94
Williamstown,	—	.27	.21	.37	.18
Winter Hill,	6.39	.27	.18	.23	.92
Worcester,	—	.29	.07	.45	1.23
Worcester,	—	.14	.05	.20	1.57

EUROPEAN STANDARDS FOR COMPARISON (HILGARD).¹*Practical Rating of Soils by Plant Food Percentages.*²

GRADE OF SOIL.	Potash.	Phosphoric Acid.	LIME.		Total Nitrogen.
			Clay Soil.	Sandy Soil.	
Poor,	Below 0.05	Below 0.05	Below 0.10	Below 0.05	Below 0.05
Medium,	0.05–0.15	0.05–0.10	0.10–0.25	0.10–0.15	0.05–0.10
Normal,	0.15–0.25	0.10–0.15	0.25–0.50	0.15–0.20	0.10–0.15
Good,	0.25–0.40	0.15–0.25	0.50–1.00	0.20–0.30	0.15–0.25
Rich,	Above 0.40	Above 0.25	Above 1.00	Above 0.30	Above 0.25

In case of the above analyses of Massachusetts soils, the potash percentage varies from .01 to 1.02, with an average of .26; the phosphoric acid from .01 to .98, with an average of .21; the lime from .06 to 3.57, with an average of .71, and the nitrogen from .02 to 2.42, averaging .30.

¹ Soils, p. 343.² According to the late Prof. Max. Maercker of the Halle Station, Germany.

Judging from such results most of the soils can at least be classed as normal from a chemical standpoint, some of them good and a few rich. Practically all of them are quite suitable for crop production if properly handled. One, however, would not care to say, from a chemical analysis alone, whether any one of them was suited to a particular crop, so many other conditions entering into the problem. Brooks, in Circular No. 29 of this station, has made this matter clear, as follows:—

1. *The Crop Adaptation.*—While the chemical condition of a soil is not altogether without influence in determining the crops to which it is suited, this, as a rule, at least within such range of soil variation as exists in this State, plays a much less important part than mechanical and physical peculiarities. The crops to which a soil is suited are determined chiefly by its drainage, its capacity to hold and to conduct water, its temperature and its aëration, and these in turn are determined by the mechanical structure of the soil and sub-soil. Variations in the proportions of gravel, sand, silt and clay, and not in chemical composition, cause the usual differences in these respects. The varying proportions of these, therefore, usually determine the crops to which a soil is suited.

2. *Fertilizer Requirements.*—The results of a chemical analysis of a soil do not, as a rule, afford a satisfactory basis for determining manurial requirements. The chemist, it is true, can determine what the soil contains, but no ordinary analysis determines with exactness what proportion of the several elements present is in available form for the crop. Indeed, there is no such thing as a constant ratio of availability. While one crop finds in a given soil all the plant food it requires, another may find a shortage of one or more elements. Further, on the very same field one crop may find an insufficient amount of potash; another may find enough potash for normal growth, but insufficient phosphoric acid; while a third may suffer only from an insufficient supply of nitrogen.

Most of our soils are of mixed rock origin, and, as a rule, possess similar general chemical characteristics, providing they have been farmed under usual conditions. The manurial and fertilizer requirements are determined more largely in most soils by the crop than by peculiarities in the chemical condition of the soil.

3. *Crop Diseases.*—The chemical composition of the soil may in some instances exercise a controlling influence in determining a condition of health or disease, and is never unimportant from the standpoint of vigorous, normal and healthy growth; but in the case of most diseases, the immediately active cause is the presence of a parasitic fungus, and this fungus is usually capable of fixing itself upon the

plant, whatever may be the composition of the soil. A knowledge of the chemical composition of soils, therefore, will not make it possible to advise such manurial or fertilizer treatment as will insure immunity from disease.

CONDITIONS UNDER WHICH ANALYSES WILL BE MADE.

For the reasons which have been briefly outlined, the chemical analysis of soils does not, as a rule, afford results which have a value commensurate with the cost; and this station, therefore, will not make such analysis unless the soil differs widely from the normal in natural characteristics, or has been subjected to unusual treatment of such a nature as to probably greatly influence its chemical condition. In order that we may decide whether analysis seems called for, correspondents are urged to write before taking samples, and when doing so to state all the conditions as fully as possible. This statement should include a full description of the soil and as full a report as possible as to the manures and fertilizers applied and crops raised for a number of years previous to the date of writing. In all cases in which, on the basis of the information given, it appears that a chemical analysis promises results of value, such an analysis will be made, and for the present free of charge; but, as explained in the preceding paragraphs, such analyses appear to be only rarely worth while. It will usually be possible to give helpful advice in relation to the use of manures and fertilizers on receipt of a full statement as to the character and history of the soil and the crop which is to be raised, and such advice will always be gladly given.

In case analysis is regarded as desirable, full directions for taking and forwarding samples will be sent.

INDEX.

INDEX.

	PAGE
Agricultural chemicals, etc., compilation of analyses of,	304
Agriculturist, report of,	34
Alfalfa, co-operative experiments with,	22
<i>Alternaria</i> in connection with gummosis,	172
Ammonia, sulfate of, quality of,	65
Analyses, tables of,	246
Tabulation of,	53
Animal excrements, compilation of analyses of,	322
Animal nutrition, research work in,	53
Apiaries, inspection of,	30
Apple, acidity as affected by temperature,	222
Approximate composition of varieties,	235
Astringency as affected by temperature,	223
Average analyses of varieties,	189
Belts of North America,	205
Characteristics of varieties:—	
Baldwin,	192
Ben Davis,	194
Esopus,	192
Fameuse,	190
Grimes,	191
Jonathan,	191
King,	191
Maiden Blush,	190
McIntosh,	190
Northern Spy,	192
Rhode Island Greening,	192
Rome Beauty,	193
Roxbury Russet,	194
Stayman Winesap,	193
Smith Cider,	193
Wealthy,	190
Winesap,	193
Yellow Newtown,	193
York Imperial,	194
Chemical examination of,	232
Color as related to temperature,	226
Coloration as affected by temperature,	223
Color of,	226
Distribution of varieties:—	
Baldwin,	214
Ben Davis,	210
Esopus,	213
Fameuse,	210
Grimes,	211
Jonathan,	211
Maiden Blush,	209
McIntosh,	210
Northern Spy,	214

	PAGE
Apple, distribution of varieties — <i>Concluded.</i>	
Oldenburg,	207
Rhode Island Greening,	213
Rome Beauty,	217
Shockley,	220
Tompkins King,	212
Wealthy,	208
Winesap,	215
Wolf River,	208
Yellow Newtown,	218
York Imperial,	217
Influence of heat of summer on,	221
Insoluble solids as affected by temperature,	223
Keeping quality,	225
Lack of flavor in,	226
Mealiness of,	226
Mean summer temperature for varieties,	229
Mean summer temperature in relation to development,	221
Modifying effect of climate on development of,	199
Modifying effect of climate on form,	199
Modifying effect of climate on general development,	205
Modifying effect of climate on size,	204
Optimum mean summer temperature,	227
Optimum temperatures by groups,	231
Premature dropping,	225
Relation of temperature to development,	221
Rotting on the tree,	225
Scalding in storage as related to climate,	224
Seasonal variation in form,	199
Size as affected by temperature,	223
Size as related to temperature,	226
The development of the,	183
The perfectly developed,	186
Uneven ripening as related to climate,	224
Varieties, climatic adaptations of,	177
Varieties, climatic adaptations of summarized,	243
Variation in form in different parts of the tree,	203
Winter minimum temperature in relation to development,	221
Apples, causes of varietal variation,	179
Climatic variation,	180
Cultural variations,	179
Individuality of the tree,	194
Soil variation,	180
Arsenates, iodine method for,	129
Arsenic, determination in insecticides,	122
Iodine method for determining,	124
New processes for determining in insecticides,	125
Practice in determining at Massachusetts station,	127
Ashes, lime compounds and marls, compilation of analyses of,	310
Ashes, wood, quality of,	64
Asparagus, breeding experiments in substation,	24
Fertilizer experiments, Concord,	25
Nitrogen fertilizers and potash salts for,	39
Substation, Concord,	24
Asparagus roots, chemical work on,	25
Soluble carbohydrates in,	135
Basic slag phosphate, quality of,	66

	PAGE
Black knot, <i>Plowrightia morbosa</i> ,	169
Black spot or scab, appearance on fruit,	166
Appearance of the leaves,	166
Appearance on the twigs,	166
<i>Cladosporium carpophyllum</i> , Thum.,	165
Blood, dried, quality of,	65
Bone, dissolved, quality of,	63
Ground, quality of,	63
Botanist, report of,	75
Brown or fruit rot, <i>Monilia</i> ,	161
Symptoms on flowers,	162
Symptoms on fruit,	162
Symptoms on the leaves,	164
Symptoms on the twigs,	163
Peach and plum, methods of control,	164
Buildings,	30
By-products and refuse substances, compilation of analyses of,	314
Candidates for Babcock test, examination of,	69
Carbohydrates, soluble, in asparagus roots,	135
Castor pomace, quality of,	65
<i>Cercospora circumscissa</i> ,	170
Chemical department, summary of work in,	51
Chemical research, laboratory work in,	52
Chemicals and refuse salts, compilation of analyses of,	304
Chemist, report of,	51
<i>Cladosporium carpophyllum</i> , Thum.,	165
<i>Cladosporium</i> in connection with gummosis,	172
Climatic adaptations of apple varieties,	177
Commercial shortages (fertilizers),	59
Control work,	28
Corn fertilizer <i>v.</i> fertilizer richer in potash,	45
Correspondence,	20
In chemical department,	51
Cottonseed meal, quality of,	65
Cows, pure-bred, testing of,	74
Cranberry, fertilizer experiments in substation,	27
Insect work,	28
Substation,	26
<i>Cylindrosporium Padi</i> ,	170
Dairy law,	29
Execution of,	69
Dairy products, compilation of analyses of,	247
Table of analyses of,	272
Demonstrations, lectures and,	20
Determination of arsenic in insecticides,	122
Digestion coefficients obtained with poultry, average,	302
Digestibility, tables of, literature consulted,	303
Director, report of,	13
Entomologist, report of,	77
Ethyl esters, distillation of, in vacuo,	133
<i>Exoascus deformans</i> ,	167
<i>Exoascus pruni</i> ,	169
Experiments, general,	21
Extension work, future provision for,	20
Fatty acids, crystallization from alcohol,	132
Distillation in vacuo,	131
Purification of,	131

	PAGE
Feed and dairy section, miscellaneous work in,	73
Report of,	67
Feed law,	29
Analytical work under,	67
Compliance with,	68
Execution of,	67
New law needed,	68
Feeds, weight of sacked,	69
Feldspar, non-availability of,	42
Fertilizer ingredients of fodder articles,	266
Fertilizer ingredients, trade values of,	56
Fertilizer law,	28
Fertilizer section, miscellaneous work of,	66
Report of,	54
Fertilizers, analyzed,	55
Collected,	55
Commercial shortages in,	59
Complete, analyses compared with guarantees,	57
Comparative cost of plant food in different grades,	62
Composition of different grades,	61
Grades of,	60
Licensed,	54
Quality of plant food in,	60
Unmixed,	63
Fish, dry ground, quality of,	63
Fodder articles, coefficients of digestibility,	273
Experiments with calves,	301
Experiments with horses,	299
Experiments with poultry,	300
Experiments with ruminants,	274
Experiments with swine,	296
Fodder articles, compilation of analyses of,	247
Composition and digestibility of,	249
Digestibility of American, coefficients of,	273
Fertilizer ingredients in, tables of,	266
Food stuffs, definition of,	69
Fruit and garden crops, compilation of analyses of,	324
Fruits, fertilizer constituents of,	325
Relative proportion of phosphoric acid, potash and nitrogen in,	334
Garden crops, compilation of analyses of,	324
Fertilizer constituents of,	327
Nitrogen fertilizers and potash salts for,	38
Relative proportion of phosphoric acid, potash and nitrogen in,	334
Glassware, examination of,	70
Gössman, Charles Anthony, tribute to,	80
Guanos, compilation of analyses of,	309
Gummosis, histological changes accompanying,	173
Of the peach,	171
On fruit-bearing wood,	172
Probable cause of,	171
Suggestions for treatment of,	174
Hay, top-dressing for,	48
Information, dissemination of,	16
Insecticides, compilation of analyses of,	323
Determination of arsenic in,	122

	PAGE
Iodine method for arsenates,	129
For determining arsenic,	124
Kainit, influence on hay crop,	41
Leaf curl of peach,	167
Lectures and demonstrations,	20
Lime compounds, compilation of analyses of,	310
Lime-sulphur solution, concentrated,	176
Machines, Babcock, inspection of,	70
Mailing lists, numbers in,	19
Manure <i>v.</i> manure and sulfate of potash for hay,	44
Manure, winter, <i>v.</i> spring application of,	48
Marl, compilation of analyses of,	310
<i>Monilia</i> , spore dispersal of,	164
Spores of,	164
Milk, composition of, effect of protein on,	86
Cream and feeds, free examination of,	72
Milk secretion, studies in,	86
Conclusions,	120
Milk yield and shrinkage,	118
Muriate compared with sulfate of potash,	36
Muriate of potash, influence on rowen crop,	42
Nitrate of soda, quality of,	65
Nitrogen, comparison of materials as sources of,	34
Nitrogen fertilizers for garden crops,	38
Relative efficiency of,	35
Nutrients, effect on weight of animals,	89
Onions, nitrogen fertilizers and potash salts for,	40
Organization,	11
Papers, technical, list of,	23
Peach and plum troubles,	161
Peach gummosis,	171
Peach leaf curl, <i>Exoascus deformans</i> ,	167
Peach shot hole, <i>Cercospora circumscissa</i> ,	170
Phosphates and guanos, compilation of analyses of,	308
Phosphates, comparison of,	42
Phosphoric acid compounds, quality of,	66
<i>Plowrightia morbosa</i> ,	169
Plum leaf spot, <i>Cylindrosporium Padi</i> ,	170
Plum pockets, <i>Exoascus pruni</i> ,	169
Potash compounds, quality of,	65
Potash, low-grade sulfate, influence on rowen crop,	42
Muriate and sulfate compared,	36
Potash salts for garden crops,	38
Relative value of different,	40
Protein, influence on composition of milk,	86, 109
Influence on milk shrinkage,	119
Influence on milk yield,	86, 90, 108
Publications,	16
Available for distribution,	17
Circulation of,	18
Purification of insoluble fatty acids,	131
Refuse substances, compilation of analyses of,	314
Report of agriculturist,	34
Botanist,	75
Chemist,	51

	PAGE
Report of director,	13
Entomologist,	77
Feed and dairy section,	67
Fertilizer section,	54
Treasurer,	33
Research,	23
Rock, ground, comparative worthlessness of,	64
Rusts, an outbreak of,	144
Seed germination records, tables of,	141, 142
Seed work, 1910,	141
Shot hole effect caused by improperly mixed Bordeaux,	170
Soil test, north acre,	47
South acre,	46
Spinach disease new to Massachusetts,	146
Staff, changes in,	13
Station staff,	11
Strawberries, nitrogen fertilizers and potash salts for,	39
Stump growths, abnormal, conclusions relative to,	159
Experiments in inoculation,	154
Leaves, chemical test of,	157
Relation of root area to intensity of disease,	156
Relation to mosaic disease,	154
Abnormalities of,	149
Sulfate of potash compared with muriate,	36
Summer spray mixture, directions for making,	174
Sweet pea troubles,	145
Tankage, quality of,	63
Top-dressing for hay,	48
Trade values of fertilizing ingredients,	56
Treasurer, report of,	33
Work, lines of,	16

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JANUARY, 1911.

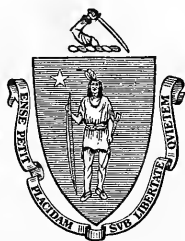


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PART II.
GENERAL REPORT OF THE EXPERIMENT STATION.

CONTENTS.

PART II.

	PAGE
Summary of leading conclusions, by the director,	7
Top-dressing permanent mowings,	10
General plan,	11
Slag meal and muriate of potash both with and without nitrate of soda,	12
Slag meal and low-grade sulfate of potash both with and with- out nitrate of soda,	13
Slag meal and high-grade sulfate of potash both with and with- out nitrate of soda,	13
General observations on results,	14
Method of applying fertilizers,	17
Top-dressing pastures,	18
Conditions under which likely to be profitable,	20
Materials used in top-dressing,	21
Season for top-dressing,	23
Alfalfa in Massachusetts,	24
Number of crops per year, and yield,	24
Conditions essential to success with the crop,	25
Topography,	25
Soil,	25
Necessity for lime,	26
Fertilizer requirements,	26
Seeding to alfalfa,	27
Season for sowing,	27
Preparation of the soil,	28
Nurse crops for spring sowing,	29
Preparation for summer sowing,	29
Date of sowing,	29
Alfalfa seed,	30
Quantity of seed,	30
Inoculation,	30
Diseases of alfalfa,	31
Harvesting alfalfa,	32
Top-dressing alfalfa,	33
Secondary value of alfalfa,	33

	PAGE
Experiments relating to the prevention of the clogging of drain tile	
by roots,	35
Results of pot experiments,	36
Experiments in boxes,	39
The clogging of drain tile by roots,	43
The spraying of trees,	47
Shade tree troubles,	52
The chestnut disease (<i>Diaporthe parasitica</i>),	56
Crown gall,	58
Fusarium disease of cucumbers and other plants,	62
Condition of fruit trees in general,	66
A new type of spray nozzle,	69
Distillery and brewery by-products,	72
Distillers' dried grains,	72
Brewers' dried grains,	76
Malt sprouts,	80
The feeding value of apple pomace,	84
The effect of protein upon the production and composition of milk,	87

MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, MASS.

TWENTY-THIRD ANNUAL REPORT.

PART II.

SUMMARY OF LEADING CONCLUSIONS.

WM. P. BROOKS, DIRECTOR.

The papers included in this part of the annual report cover a wide variety of subjects, and many of them are of such a character that the conclusions cannot be briefly stated. A full list of the papers is included in the table of contents, and in cases where deemed desirable the principal sub-topics are included. The papers themselves are concise, and should be read in full by those interested in them. Some of the more important conclusions may be stated as follows:—

1. Profitable hay crops may be produced in permanent mowings by top-dressing with fertilizers only.

2. A combination of slag meal and a potash salt produces hay made up chiefly of Kentucky blue grass and white clovers. The addition of nitrate of soda in amounts varying from 150 to 200 pounds per acre is usually profitable. The hay produced ranks exceptionally high in nutritive value, especially where the slag meal and potash only are used.

3. The use of slag meal and low-grade sulfate of potash is strongly recommended as a top-dressing for pastures. In experiments continuing two years it has profoundly modified the character of the herbage, the most striking change being a re-

markable increase in the proportion of white clover. It is estimated that the amount of feed now produced is at least three times as great as that on the part not top-dressed.

4. Experiments and observations lead to the conclusion that alfalfa can be successfully grown in Massachusetts. Experiments with the crop are urged. The type of soil, and the method of fertilization and sowing believed to be best are described.

5. It has been found that either excelsior or sawdust first saturated with creosote and packed about the joints of drain tiles prevents the entrance of roots, while at the same time the treatment seems to protect the materials used from decay.

6. The conditions under which roots are likely to penetrate drain tiles are described, and observations are presented which indicate under what conditions the roots of trees are found to be particularly dangerous.

7. Spraying shade trees by the methods first perfected for fruit trees is found to be exceedingly costly. The equipment essential both for satisfactory work and to insure the least possible cost is described. Briefly, powerful machinery capable of maintaining a pressure of 200 to 250 pounds per square inch and special types of nozzles are recommended.

8. Some of the more important of the agencies acting unfavorably on our shade trees are described. The more important are contact with wires of telephone, electric light and trolley lines, putting in of water mains and gas pipes, marked deficiency in rainfall and severe climatic conditions. These appear to have caused extensive root killing and gradual death of the trees, while both sun scald and sun scorch have seriously injured some species. The methods of distinguishing between injuries due to the several causes are carefully presented.

9. The fact that the chestnut disease seems to be gaining a foothold in Massachusetts is stated, and the localities are mentioned where it has been found. It is suggested that the unfavorable condition of the trees due to climatic causes may have rendered them peculiarly susceptible. Owners of chestnut lumber of merchantable size where the disease is found are advised to cut at once.

10. The extent to which crown gall affects fruit trees, and the nature and probable seriousness of the disease are dis-

cussed. The importance in the purchase of nursery stock of securing trees from localities free from this disease is urged.

11. The occurrence of a fusarium disease of cucumbers and allied plants, the first symptom of which is wilting which usually results in the death of the plant is pointed out. This at present affects chiefly hothouse crops, but in some localities is found in out-door crops. In the case of hothouse crops, excessive crowding and forcing seem to produce plants with tissues peculiarly susceptible. Growers are advised against such treatment.

12. The fact that large numbers of fruit trees of all kinds are in unsatisfactory condition due to unfavorable climatic causes, and the presence of San José scale is pointed out. The gradual death of the feeding roots due to the excessive drought and extreme cold, the presence of sun scald often followed by canker are among the more important results. Methods of treatment are suggested.

13. The essential features of a satisfactory nozzle for spraying, especially the larger trees, are described; and briefly stated, the most essential points appear to be the capacity to throw the material long distances and yet to break it into a mist-like spray. A nozzle believed to be a great improvement on any type previously made is described and illustrated.

14. The general character, digestibility and the best methods of use of distillery and brewery by-products are stated, and rations for different classes of farm animals are suggested.

15. The composition, digestibility and feeding value of apple pomace lead to the conclusion that if used in a balanced ration about four pounds of the pomace will equal in value one pound of good hay.

16. The minimum digestible protein needed daily by a cow weighing 1,000 pounds and yielding 20 pounds of milk is about 1.4 pounds; but an increase of about 35 to 50 per cent above this amount seems likely to yield profitable returns. For a 900 pound cow giving 12 quarts of milk per day about 1.8 pounds of digestible protein in the feed daily should be satisfactory. An increase in the protein above the minimum does not appear to affect the composition of the milk.

TOP-DRESSING PERMANENT MOWINGS.

BY WM. P. BROOKS, DIRECTOR.

Between the County Road and that portion of the college estate where the dormitories stand lies an area of about 30 acres which is treated as a part of the campus. It is crossed by numerous foot paths and portions of it are occasionally used for company or battalion drill. The surface is rolling and the soil of somewhat variable character; for the most part, however, it is a strong retentive loam, well suited for grasses and clovers. The greater part of this area has certainly not been plowed during the past twenty-two years and probably not for a considerably longer period. It was in 1889 that the writer of this article first became responsible for its management. At that time much of it had the appearance so common throughout New England of a somewhat neglected mowing, although it was much more productive than such mowings usually are. The prevalent species of grass were Kentucky blue and sweet vernal. In places there was considerable orchard grass, and meadow fescue was abundant especially in the moister places. Whiteweed (*Chrysanthemum leucanthemum*) was extremely abundant in all the drier portions. Dandelions, buttercups and common plantain were very abundant in places. Some portions of this area have been plowed and reseeded during the period intervening since 1889, but on most of it an effort has been made both to eradicate the weeds and to improve the product both in quality and quantity by top dressing without plowing and reseeded. This seemed desirable in view of the preference of college authorities to treat this area like a campus rather than as farm land.

The most effective method for the eradication of the whiteweed has been found to be early cutting to prevent ripening of seed, and top dressing with materials favorable to the

clovers and grasses. In such portions of the area as have been plowed and reseeded, it has always been found that we had a crop of whiteweed to contend with. Undoubtedly the soil, formerly rather indifferently managed, like that of so many of the New England farms, is heavily stocked with seeds of this as well as of many other weeds, and every time it is turned over conditions have been made right for the germination of some of those which have previously been buried too deeply to germinate.

The statement of the conditions affecting this area must have made it apparent that they do not afford a satisfactory basis for close comparison on limited areas. The total area involved, however, is so large that the unequalities and disturbing conditions which have been referred to are somewhat equalized and it was therefore thought to be worth while a few years since to undertake comparisons between different fertilizer combinations with a view to affording at least object lessons on the possibilities of modifying and improving the herbage in permanent grass land by varying use of fertilizers.

GENERAL PLAN.

In each of the principal sections into which the area is naturally divided by roads and principal walks, a few half-acre sections were laid off and throughout the period of the experiment, which is now some six years, these have received no fertilizer whatever. In two of the natural subdivisions of the area, plots of substantially one-half acre each have been laid off and these throughout the entire period have been fertilized annually with nitrate of soda only at the rate of 150 pounds per acre.

On the balance of the entire area basic slag meal has been applied annually at the rate of 500 pounds per acre. This on different sections of the area has been used in connection with the different leading potash salts as follows: —

(1) On that portion of the area lying north of the "Cross Walk" so-called, the potash salt used is muriate at the rate of 150 pounds per acre.

(2) On that portion of the area south of the Cross Walk

and west of the college pond and the stream which runs into it, high grade sulfate of potash is used at the rate of 150 pounds per acre.

(3) On the balance of the area which lies south of the Cross Walk and east of the college pond and stream, the potash salt used is the low grade sulfate at the rate of 300 pounds per acre.

With each of these differing combinations we are applying nitrate of soda on about one-half of the total area to three substantially equal plots. The rates respectively are 150, 200 and 250 pounds per acre.

Owing to the large area covered by these experiments, and the varying conditions as to weather, often showery, in which hay must be handled, it has been found difficult to obtain weights which are strictly comparable. The general results have, however, been clearly apparent, and the following figures, based upon such weights as have been taken during the past three years, in a measure indicate what they have been.

1. SLAG MEAL AND MURIATE OF POTASH BOTH WITH AND WITHOUT NITRATE OF SODA.

In the section of the field where these fertilizers have been used, the yields on the plots to which no fertilizer has been applied have varied between 867 and 1,833 pounds per acre. The average for the past three years has been 1,419 pounds per acre.

Top-dressing with slag meal and muriate of potash produced an increase in crop which has varied during the past three years from 1,588 to 1,902 pounds per acre. The average increase has been at the rate of 1,714 pounds per acre. The total crop produced where slag meal and muriate of potash have been applied as top-dressing has averaged 3,133 pounds per acre.

The gain resulting from top-dressing with nitrate of soda at the rate of 150 pounds per acre in connection with the slag and muriate of potash has varied between 557 and 1,205 pounds per acre.

The use of 200 pounds of nitrate of soda per acre has produced an increase varying from 543 to 2,775 pounds, the average for the past three years being 1,419 pounds per acre.

The use of 250 pounds of nitrate of soda per acre in connec-

tion with slag and muriate of potash has produced an increase varying from 736 to 2,265 pounds per acre, the average being 1,283 pounds per acre.

The figures above given have all referred to the first crop. In years characterized by normal rainfall these fields have always produced a moderate crop of rowen, but the past two seasons have been so abnormally deficient in rainfall that the rowen crops have been small, — in some years, indeed, so small that the fields have not been cut. The amount of rowen produced on plots where nitrate of soda is used in connection with the slag and potash has been less than where the slag and potash alone have been used. This difference, it will be readily understood, is due to the fact that clover is relatively more abundant on those portions of the field where slag and potash alone are applied.

2. SLAG MEAL AND LOW-GRADE SULFATE OF POTASH BOTH WITH AND WITHOUT NITRATE OF SODA.

It has so happened that we have but few weights that can be regarded as entirely reliable pertaining to the results on the field where these fertilizers are employed; but examinations of the fields at various times have shown that the result of the employment of slag and low-grade sulfate of potash alone has been a remarkable increase in the proportion of white clover, which has attained a height and luxuriance that the writer has seldom seen equaled. The increase in crop resulting from the application of this combination of fertilizers has clearly been large. The employment of nitrate of soda in connection with slag and low-grade sulfate of potash in amounts varying from 150 to 250 pounds per acre on different plots has resulted in a very small increase.

3. SLAG MEAL AND HIGH-GRADE SULFATE OF POTASH BOTH WITH AND WITHOUT NITRATE OF SODA.

In one section of the field the plots top-dressed with slag and high-grade sulfate of potash have given a yield of hay during the past three years varying from 2,732 to 3,866 pounds per acre, the average being 3,351 pounds per acre.

In this field nitrate of soda is used on one plot in connection with the slag meal and high-grade sulfate of potash at the rate of 200 pounds per acre. This has given an increase, as compared with the plots to which the slag and potash alone are applied, varying from the insignificant amount of 26 pounds to 3,375 pounds per acre in one year. The average increase for the three years was at the rate of 1,479 pounds per acre.

In another section of the field slag meal, high-grade sulfate of potash and nitrate of soda in three different amounts have been applied. The increases produced during the past three years have been at the following rates per acre: —

For the slag, high-grade sulfate of potash and 150 pounds of nitrate of soda per acre, 2,730 to 4,220 pounds, the average being 3,279 pounds.

For the slag, high-grade sulfate of potash and 200 pounds of nitrate of soda per acre, 2,460 to 2,960 pounds, the average being 2,710 pounds.

For the slag, high-grade sulfate of potash and 250 pounds of nitrate of soda per acre, 2,080 to 5,470 pounds, the average being 3,747 pounds.

GENERAL OBSERVATIONS ON RESULTS.

The character of the vegetation has been greatly influenced by the system of management which has been followed. The most marked effects are the following: —

(1) The amount of white weed produced has greatly decreased in all portions of the field which have been top-dressed, and especially on those which have been top-dressed without reploting. The same is true, though to a somewhat less extent, concerning the buttercups and plantain. The dandelions, which come up very early in the spring, before the grasses and clovers have made much growth, are still relatively abundant.

(2) On those parts of the field which have not been top-dressed bluets (*Houstonia cœrulea*) are becoming increasingly abundant, while the yield of hay has become very small, usually varying between 1,000 and 1,500 pounds per acre.

(3) On all parts of the field top-dressed with a combination of slag meal and a potash salt, the clovers have become very

abundant. They appear to be somewhat less abundant on the muriate of potash than on the sulfates, and there seems to be a difference in the relative proportions of white and red clovers on the two sulfates, the former being relatively most abundant on the low-grade sulfate, while the red clover has been most luxuriant on the high-grade sulfate of potash. It should be remembered, in estimating the significance of this observation, that no seeds of any kind have been sown in these fields; and it is further important to keep in mind the fact that the soil conditions, as has been indicated, vary quite widely in different portions of the area under consideration. It may be, therefore, that the differences in proportion of white and red clovers just referred to are due either to accidental conditions or to variations in soil, and not to the difference between these two salts.

(4) The use of slag and either of the potash salts produces on the average an increase in the crop considerably more than sufficient to pay the cost of top-dressing with these materials. The results demonstrate the ability of soils naturally adapted to grass to produce profitable hay crops without frequent re-plowing.

(5) Close observation of the crops produced and of the general conditions prevailing leads to the conclusion that these fields are improving from year to year. The proportion of weeds is decreasing, while that of clovers is increasing.

(6) The use of nitrate of soda in connection with slag meal and a potash salt usually gives a considerable increase in the hay crop, in most cases more than sufficient to pay the cost; but an application at the rate of 250 pounds per acre appears to be in excess of requirements. If the season is characterized by normal or abundant rainfall, the crops receiving nitrate of soda at this rate almost invariably lodge badly, and, as a result, the yields are somewhat lessened. During years with abundant rainfall, nitrate of soda at the rate of 150 pounds appears to give as much increase in the crop as is produced by nitrate in any larger amount, and while the yield on 200 pounds sometimes exceeds that produced by the lesser amount, it is the writer's belief that the 150-pound rate for mowings similar to

those under consideration will usually be found most profitable.

(7) The proportion of clover on those portions of the field receiving nitrate of soda in connection with slag meal and a potash salt is somewhat less than where the slag and potash salt are used alone, but the product is still characterized by a liberal proportion of clovers.

(8) The product of these fields has exceptionally high nutritive value. The hay is made up of a large variety of grasses, principally Kentucky blue grass, sweet vernal and fescues, with considerable orchard grass in some portions of the fields. It contains, as has been pointed out, a very large proportion of clover, and it contains also a considerable proportion of a number of different species, some of which have been mentioned, commonly looked upon as weeds. It will be recognized that such a product would not ordinarily sell well in the markets. It is, however, exceptionally palatable to cattle, and it has been noted again and again that milch cows, when receiving it in connection with liberal grain rations, give a considerably larger yield of milk than when fed on the best of mixed timothy, red top and clovers in connection with similar grain rations. This difference seems usually to amount to about 10 per cent. more milk on the product of these permanent mowings. The superintendent of the college farm, who during the past year or two has had some experience in feeding good alfalfa hay to milch cows, and who is a close observer, has recently stated that he believes the product of these old fields to be superior to the best alfalfa hay as a food for milch cows.

The facts to which attention has just been called lead to the conclusion that where the production of hay for market is the object, such a system of management as is used in these fields is not likely to give satisfactory results, but where hay is to be fed to stock on the farm, especially to cows or sheep, the system has much to commend it under certain conditions.

It is not infrequently the case that certain of the fields of the farm lie at such distances from the farmstead that their use in the production of hoed crops is impracticable. It is out of the question to haul manure to them. The conditions affecting

farm labor may render it rather impracticable to break them up and reseed them frequently. Under such conditions, such fields as we are considering on many farms are simply neglected. The product of hay soon sinks to less than a ton to the acre and hardly pays the cost of cutting. For such fields the system of top-dressing with slag meal and a potash salt, either without nitrate of soda or in connection with a small amount of that material is likely to be profitable.

METHOD OF APPLYING FERTILIZERS.

In the experiments to which reference has been made, the fertilizers have invariably been applied in spring, and this will probably, as a rule, be the best season. It should be the rule to make the application at about such time as grass fairly begins to grow, and this in average seasons will usually be between about the 20th of April and the 1st of May.

TOP-DRESSING PASTURES.

BY WM. P. BROOKS, DIRECTOR.

The results obtained in top-dressing the permanent mowings, which comprise a large proportion of the college campus, have demonstrated most conclusively that the character and growth of the forage produced may be profoundly modified by the nature of the fertilizer applied. It was early noticed that the continued, moderate use of basic slag meal and a potash salt had a marked effect upon the proportion of clovers, and therefore upon the nutritive value of the hay produced. This hay is made up largely of Kentucky blue grass and white clover, and is found to be much superior as forage for milch cows to the best grades of hay (composed of timothy, red top, alsike and red clovers) produced in our rotation mowings, these mowings being usually cropped two years in corn and then from two to four years in hay.

These observations led to the belief that similar systems of top-dressing would prove highly beneficial to many of our pastures. These, as is generally recognized, are often of very inferior character. On the average, several acres are required to yield pasturage for a single cow, and this even in the case of pastures free from brush or other obstructions. In the Connecticut valley, especially, in the month of May, when the young grasses and clovers should be making a vigorous growth, producing rich green turf, it is common to find pastures almost as white as the driven snow with a thick crop of bluets (*Houstonia cærulea*), while the grasses are making little growth and white clover is scarcely to be found. In many cases close examination shows areas where mosses are replacing the grasses. Such conditions indicate a sour soil, and such pastures will produce relatively little feed.

In the spring of 1909 an experiment in top-dressing was

begun in one of these pastures in the northern part of the town of Amherst, on the farm of Herbert S. Dickinson. The portion of the pasture selected was level and entirely free from brush and stones. It is land which was under cultivation a considerable number of years ago. The soil is made up principally of the finest grades of sand and silt, and is quite retentive of moisture. The amount of feed produced in recent years had been small, and the pasture presented the characteristics above referred to in their most typical development.

Four plots of equal area in a part of the pasture, seemingly of very even quality, were laid off. Plots 1 and 3 received an application of basic slag meal and low-grade sulfate of potash (sulfate of potash-magnesia), mixed together before spreading at the following rates per acre: basic slag meal, 500 pounds; low-grade sulfate of potash, 300 pounds. Plots 2 and 4 were left untreated. The materials referred to were applied in the early spring. Before the end of the first season there was a marked difference in the character of the growth upon the fertilized and unfertilized plots. On the former, white clover was found to be coming in, while the grasses showed a much greener color and more vigorous growth.

The pasture in which these plots lay was heavily stocked with milch cows throughout the summer, and it was observed that they grazed upon the top-dressed plots a much larger proportion of the time than on the untreated plots, or the other portions of the pasture.

In the spring of 1910 the top-dressing of plots 1 and 3 was repeated. The differences of the previous season which have just been referred to became still more marked, and the preference of the cows for the forage produced on these plots became yet more noticeable. As a result of the superior character of the forage produced on the top-dressed plots, and the preference of the cows for feeding upon them, they were kept much more closely grazed throughout the entire season, and were especially far more closely grazed late into the autumn than is favorable to the best development. It is fair to suppose, therefore, that the fertilizers applied would have produced yet more marked effects under more favorable conditions. In

spite of these facts, however, the change in the character of the herbage, shown by examination early in the month of May, 1911, is nothing less than astonishing. In place of the dull, lifeless, moss-infested turf, thickly starred with bluets, we find in these plots a rich, green turf, in which white clover is much the most prominent species. Indeed, so thick is the clover in these plots that in most places it constitutes a perfect mat. This change, it should be pointed out, is the result simply of such modification of the soil conditions as fits it for clovers, for no seed of any kind has been sown. It can safely be inferred that the plots which have been top-dressed are now producing fully three times the amount of feed produced by those which have not been so treated.

From the description of the conditions under which this experiment has been tried it will be recognized that no figures can be presented which will indicate the extent of the improvement produced. An experiment is now being laid out in which two plots of equal area, one to be top-dressed and the other not, will be separately enclosed, and a record of the number of days of pasturage each affords will be kept. It will be understood that until we have this record it is not possible to state whether the improvement referred to has been produced at such cost as to make the system of top-dressing followed financially profitable. It is the belief of the writer, however, that it must have been so.

CONDITIONS UNDER WHICH LIKELY TO BE PROFITABLE.

The fact has been referred to that a large proportion of our pastures is producing relatively little feed. Whether they can be profitably improved by top-dressing is an important question. In a great many of our pastures improvement by top-dressing is the only practicable method, since, owing to the conditions existing, it is impossible to plow them. Not all pastures, however, are in such condition that top-dressing can be advised. It is not believed it will be found profitable except in those cases where the turf is mostly free from foreign growths, such as shrubs, bushes, hardhack (*spirea*) and ferns. If any considerable proportion of the area is occupied by such foreign

growths, the first step in improvement should be their removal. It has been common among our farmers to cut such vegetation in their pastures from time to time. My observation convinces me that this treatment is usually disappointing in results. At whatever season of the year such vegetation is cut it is likely to spring up again, and it may be cut year after year for a long series of years and still not be exterminated. While the initial outlay is, of course, much heavier, results ultimately much more profitable and satisfactory will, in my judgment, be obtained by uprooting bushes, etc., at the outset of any efforts towards improvement. When cleared of foreign vegetation a pasture may, in many cases with advantage, be harrowed and seeded if the surface is much broken as the result; but if the obstructions have been widely scattered, it may be advisable simply to level the areas dug up in connection with the removal of the foreign vegetation and to seed those areas only. Kentucky blue grass and white clover will be more useful than any other varieties, and will, I think, as a rule be the only kinds desirable. After the surface has thus been cleared, such pastures, as well as those which are now clear, may be expected to repay judicious top-dressing.

It may be here pointed out that improvement of our pastures will not only increase the amount of stock which a farmer can keep, but it will be likely to increase the milk yield of a given number of cows, since in improved pastures the animals will be able to gather sufficient food in a much smaller number of hours, and will have leisure to ruminate, and to convert a larger portion of the feed consumed into milk.

In pastures in which the surface is occupied in considerable measure by rocks, top-dressing is of course likely to prove less profitable than in those which are free from such obstructions. It will be apparent, further, that the more nearly level the pasture the less probability that the materials used in top-dressing will be washed away.

MATERIALS USED IN TOP-DRESSING.

It is believed that the basic slag meal used in the experiments referred to is peculiarly suited to meet the requirements of a

large proportion of our pasture soils. Especially must this be true of those naturally poor in lime, with soils which are retentive of moisture, and where white clover is scantily produced. Slag meal is likely to produce less striking effects in pastures which now produce white clover abundantly, or in those having excessively dry soils. Its special fitness for the improvement of pastures deficient in lime and not now producing white clover is undoubtedly connected with the fact that it is rich in lime. Its tendency, therefore, is to sweeten soils which are naturally sour, and thus to bring them into condition such that clovers can thrive. It is now generally understood that clovers cannot flourish in soils containing free acid. Basic slag meal, moreover, is a relatively low-priced fertilizer, and it may be pointed out still further that it has for many years been profitably used for top-dressing pastures in various parts of Europe, especially in England.

A potash salt, as well as the slag meal or some substitute for the latter, will in almost all cases be required, for without a liberal supply of potash in the soil clovers will not thrive, and a good permanent pasture without white clover is, in our climate, practically an impossibility. There are several potash salts which might be used. Most important among these are the muriate, the high-grade sulfate and the low-grade sulfate. In the experiments described the latter has been employed. The writer was led to select it chiefly because of his observations upon the results of top-dressing with the different potash salts in the permanent mowings referred to at the beginning of this article. It appears to be peculiarly adapted to bring in white clover; but observations upon the permanent mowings, where the different potash salts are under comparison, show that either the muriate or high-grade sulfate also will increase the proportion of white clover. These salts cost rather less in proportion to the actual amount of potash they supply than the low-grade sulfate, and in localities where transportation counts as an especially important item they should perhaps be preferred, since to obtain an equal amount of potash it would be necessary to use them in only half the quantities required of the low-grade sulfate. The writer would, however, call attention to the fact

that the latter supplies a large amount of magnesia as well as potash, and that it is not unlikely that this, while inferior to potash in its effects upon clover, may nevertheless exert an influence favorable to its more vigorous development.

SEASON FOR TOP-DRESSING.

For level pastures it is the writer's belief that top-dressing with a mixture of slag meal and a potash salt had best be done in the autumn, but in all cases where the slopes are excessive it will be preferable to apply the materials in the early spring.

ALFALFA IN MASSACHUSETTS.

BY WM. P. BROOKS, DIRECTOR.

As time passes the number of successful experiments with alfalfa in Massachusetts increases. This is true not alone of the experiments in progress on the station grounds and on the college farm in Amherst, but of experiments which have been conducted by private individuals in various parts of the State as well. The question may arise, Why is the degree of success attending such experiments at present greater than in the case of the earlier experiments? It is the belief of the writer that the answer is, Because we have learned, as a result of our failures and successes, many things to avoid, and what conditions are best calculated to insure success. We now have very little difficulty in securing good catches of alfalfa, and on the station grounds and on the college farm in Amherst are a number of plots of some five or six years' standing which are yet in good condition; so that it would seem that we have not only learned what steps to take to secure a good catch, but also how so to manage as to insure a reasonable degree of permanence.

The writer would not be understood that he is as yet prepared to endorse too exclusive dependence upon alfalfa as a forage crop. He believes that there is still a considerable element of risk, but that at least the crop is worth careful trial.

NUMBER OF CROPS PER YEAR AND YIELD.

Alfalfa makes a more rapid growth in early spring than any other forage crop, unless it be rye. The first crop is usually ready to cut early in June, and at least two additional crops may be counted upon; while in seasons which are exceptionally favorable as to rainfall and other climatic conditions alfalfa may probably be safely cut four times. With three crops per

acre, which number has been the rule here, our yields in good fields have ranged from about $3\frac{3}{4}$ to $5\frac{3}{4}$ tons per acre of well-made hay for the three. Such yields are greater than those which can usually be counted upon from the clovers, or mixtures of grasses and clovers, and since in nutritive value alfalfa considerably exceeds the product of the ordinary hay field, such a yield indicates that the crop, where successful, is of unusual value.

CONDITIONS ESSENTIAL TO SUCCESS WITH THE CROP.

Topography. — Experience and observation convince the writer that fields which have a moderate slope are to be preferred to those which are nearly level. Their superiority is due to the fact that it is relatively easy, in preparing for the crop, to leave the surface of such fields in such shape that water cannot possibly stand upon any part of them, and therefore that ice will never form on the surface. Ice on the surface of an alfalfa field is sure to destroy it, and as it is almost impossible to avoid places which are slightly depressed below the ordinary level, from which there is no outlet, in fields which are nearly level, slopes should be preferred.

Soil. — Alfalfa will succeed upon a considerable variety of soils provided certain conditions exist. First and most important of these is good drainage. The writer is convinced that it would not be advisable to undertake the cultivation of alfalfa in fields in which the water table will usually be found within less than five or six feet of the surface. It is possible that a fair degree of success might be obtained with the water table from three and one-half to four feet below the surface; but in all cases where the water table is at this level the percentage of water in the surface soil is likely to be relatively large, unless the soil is of exceedingly coarse texture; and with too large a percentage of water in the surface soil heaving and winter-killing will be more probable than on soils with less moisture at the surface. What has been said suggests that the necessary depth of the water table below the surface may vary somewhat with the texture of the soil above it. Where this is coarse the water table nearer the surface than the extreme depth above in-

icated may not be productive of injurious consequences, since the capacity of the soil to conduct and to retain moisture is relatively small.

On the other hand, although alfalfa is a very deep-rooted plant, observation during the past two years, which has been characterized by exceptionally small rainfall, leads to the conclusion that it is quite sensitive to the injurious effects of extreme drought, and that soils and sub-soils of excessively coarse texture, with a water table far below the surface, can hardly be expected to give satisfactory crops. Soils which would be ranked as well adapted to grasses and clovers, provided the drainage conditions are such as have been indicated, seem likely to give the most satisfactory crops of alfalfa.

Necessity for Lime. — Alfalfa is a lime-loving crop. Success in producing it is impossible if the soil is poor in this element. The soils in many parts of this State are characterized by relative deficiency in lime, and in most localities, therefore, a moderate application of lime is necessary in preparing for alfalfa. The quantity needed will usually range between one and one-half and two tons per acre. There are a number of different forms of lime which may be made to serve the purpose. On the heavier soils freshly slaked lime or fine-ground lime will best meet requirements, since these forms of lime will at the same time improve the mechanical condition and correct the chemical faults. On the lighter soils, of coarser texture, and especially if these are deficient in organic matter, air-slaked lime or marl may be preferable. For the ordinary loams some of the various forms of so-called agricultural lime, or waste lime which has slaked in heaps at the kilns, will meet the requirements.

Fertilizer Requirements. — Alfalfa, in common with other legumes and clovers, does well only when there is a liberal supply of potash in available forms in the soil, and potash fertilizers should be freely used in preparing for alfalfa.

While the crop seems to depend in most marked degree upon an abundance of lime and potash in the soil, it is not indifferent to a supply of other plant food elements, and if the soil is not

naturally abundantly stocked with phosphoric acid, this element must be furnished.

A large amount of nitrogen in the soil cannot be regarded as essential; indeed, from some points of view it is undesirable; but, on the other hand, unless there is a fair amount of nitrogen in available forms in the soil the crop will fail to make a good start. When well established under the right conditions it can, like other legumes, draw the needed nitrogen from the air.

The application of manure to soils which are to be used for alfalfa in preparing for the crop will, it is believed, in general be found inadvisable. Manure, it is true, helps to give the soil the desired texture, and increases the proportion of humus which may be beneficial, but it usually carries many weed seeds, and increases the difficulty of getting a good catch of alfalfa. A free use of manure will, moreover, be likely to increase the competition of the grasses with the alfalfa, enabling these in a measure gradually to crowd the latter out. Manure used rather liberally for crops which immediately precede alfalfa, may, on the other hand, prove quite beneficial, especially on the lighter and poorer soils.

SEEDING TO ALFALFA.

Season for Sowing. — Success with alfalfa has been obtained both by early spring and summer sowing. In the experiments which the writer has carried out the latter has given the best results. If alfalfa is spring sown, it is commonly necessary to sow a nurse crop with it. If this is not done it must, in almost all soils, suffer greatly from the competition of annual weeds which tend to come in so freely in all fertile soils during the spring months. In the one case, then, it must share the soil with a nurse crop, in the other with weeds, and in either case the competition for plant food and moisture is somewhat unfavorable. Further, whether weeds grow up with the crop or whether a nurse crop is sown with it, the alfalfa, when these are removed, is exposed to the intense heat of the sun in midsummer, and if at this time there is a deficiency of rainfall, it almost invariably suffers a serious check.

When alfalfa is sown later in the summer it is possible to sow it alone, since by preparatory tillage the annual weeds, which tend to come in during the early part of the season, can be destroyed. Under these conditions the alfalfa is likely to make a better start than when it must meet the competition either of weeds or a nurse crop. The showers which almost invariably come in midsummer will give, in all except soils of very coarse texture, such moisture conditions as to insure quick germination of the seed.

Preparation of the Soil. — The essentials in the preparation of the soil are such tillage operations as will produce a fine seed bed and such application of fertilizers as will supply the natural deficiencies. It is a great mistake to sow alfalfa in imperfectly prepared ground. The seed bed should be as perfect as possible, and no amount of labor which is essential to produce a fine surface tilth should be spared. While the selection of fertilizers and the amounts of the several materials to be used should of course be varied to suit varying conditions, the writer recommends, as likely to prove satisfactory in the majority of cases, the following kinds and amounts per acre: —

Lime or marl,	1½ to 2 tons.
Basic slag meal,	1,500 to 2,000 pounds.
High-grade sulfate of potash,	250 to 300 pounds.
Nitrate of soda,	100 to 125 pounds.

The following method of applying the fertilizers is recommended: —

- (1) Apply the lime on the rough furrow and disk in.
- (2) Mix together the potash and all except about 200 pounds of the slag meal, apply after disking the land once and work in deeply by further disking or harrowing.
- (3) Just before the final harrowing-in preparation for the seed, mix together the 200 pounds of slag meal and the nitrate of soda, and spread this evenly and harrow it in.

In case the alfalfa is to be spring sown, apply the lime in the autumn, and if convenient apply the mixture of slag meal and potash also in the autumn, although this is less essential. It may be applied, if preferred, just before the first disking in the spring.

In the case of summer sowing, apply the lime in the early spring and immediately disk it in. A little later apply the mixture of basic slag meal and potash and disk or harrow this in deeply, and spread the nitrate of soda and 200 pounds of slag before the last harrowing.

Nurse Crops for Spring Sowing. — For nurse crops for sowing with alfalfa in spring beardless barley and oats are among the best, barley being the safer nurse crop of the two, as it is far less liable to lodge. Whichever of the two crops is selected, the amount of seed should not be too great. A bushel of barley or a bushel and a half of oats to the acre will usually be sufficient.

Preparation for Summer Sowing. — It is sometimes possible to secure good conditions for summer sowing on land used the same season for the production of a crop; but it is desirable, if this is undertaken, that the crop be one permitting of absolutely clean culture, and which can be harvested not later than about the middle of July. In the case of all soils not already highly productive and in good tilth, a summer fallow, with most careful tillage in preparation for alfalfa, is highly desirable. The very best results which have been obtained in the writer's experience have followed this method of preparation. The land is plowed in early spring, the lime and fertilizers applied as indicated above, and thereafter the soil is worked with the harrow at intervals sufficiently frequent to destroy the successive crops of weeds which are likely to start. The frequency of harrowing advisable must, of course, vary with conditions, but will usually be once in about ten days to two weeks.

Alfalfa is sometimes sown in late summer in fields of growing corn, and sometimes the results by this method are satisfactory. In the States of the middle west, where it has been most largely tried, there have been numerous failures. It is, perhaps, needless to say that if this method is to be tried the corn should not be planted over thick, its cultivation should be level and most thorough, and in fertilizing for the corn crop the needs of the alfalfa which is to be sown later in the summer must not be overlooked.

Date of Sowing. — In spring sowing, alfalfa should be put in just as early as the soil can be brought into condition. For

summer sowing the best conditions will usually occur about July 25 to August 10. If sowing is deferred much later than the middle of August, the alfalfa does not get sufficiently well rooted nor make sufficient growth to go through the winter successfully. When sown about the last of July the crop frequently attains a height of a foot before cold weather, and should on no account be cut, as this growth is needed for winter protection.

Alfalfa Seed.—No pains essential to procuring the best possible seed should be spared. Numerous varieties of alfalfa have been introduced and extensively tried in different parts of the country, and a number of them have been under trial in this experiment station. So far, however, as the experiments of the writer enable him to judge, none of the newer varieties appears to be superior to the common type of alfalfa as cultivated in our northwestern States. Northern-grown seed, bright, heavy, free from impurities of all kinds, and especially free from dodder (a parasite which, if present in any amount, will destroy the crop), should be looked for. The seeds of dodder are extremely minute, and will be easily overlooked by the casual observer. The dealer should be asked to guarantee freedom from seed of this parasite, and in all cases of doubt samples should be sent to the experiment station for examination.

Quantity of Seed.—As is the case with all farm seeds, the quantity which may wisely be sown varies with conditions, and should be greater in proportion as these are unfavorable. With the best conditions for germination, and with seed of the best quality, about 25 to 30 pounds per acre should be sufficient. A thick stand of plants is, however, of the very highest importance. When the alfalfa is thin, weeds, grasses and clovers come in, and the latter especially tend to crowd the alfalfa out. It is the belief of the writer that the quantity of seed should therefore, even under the best soil conditions, be not less than 30 pounds to the acre, and in seeding with corn it would seem to be advisable to use from 5 to 8 pounds more.

Inoculation.—It is now generally understood that legumes have the capacity to take nitrogen from the air only in partnership with bacteria which live in nodules on their roots. These

bacteria are not ordinarily present in soils where alfalfa has not previously been grown. A possible exception is afforded by soils where sweet clover (*Melilotus alba*) is indigenous and abundant. This plant, however, is comparatively rare in Massachusetts, and in almost all cases, therefore, it is advisable to bring in the appropriate alfalfa bacteria by inoculation. Two methods may be followed:—

(1) Soil from a well-established alfalfa field where root nodules are abundant may be worked into the soil where the seed is to be sown. The quantity needed will range between about 300 and 400 pounds per acre. Care should be taken that soil which is to be so used be not long exposed to the light nor allowed to dry excessively. It should be spread, if possible, towards night or on a cloudy day, and immediately harrowed in.

(2) A culture may be used. A number of different artificial cultures are now produced and recommended for the inoculation of the different legumes. The United States Department of Agriculture sends out a material known as "Nitroculture." This is in fluid form. An American agency of a European company produces and offers a jelly-like culture known as "Nitrugin." A New Jersey company sends out a culture known as "Farmogerm," which is also a jelly-like material. The writer's recent experience has been mainly with the latter, and the results have been satisfactory. Full directions for the use of cultures accompany every package, and these should be exactly followed.

DISEASES OF ALFALFA.

The only disease which has been serious in the experiments in growing alfalfa in this State is a species of rust or leaf-spot. This seems to be most likely to affect newly sown areas. The spots referred to are yellow in color. They are likely to appear first on the lower leaves of the plant; but in cases of bad infection the trouble rapidly spreads from leaf to leaf, and the entire foliage of the plant soon becomes yellowish in color and the leaves begin to fall. If the disease is allowed to take its natural course the plants, especially if young, are greatly enfeebled. Grasses and clovers under these conditions in many fields will be likely to displace the alfalfa.

No preventive treatment is known, but the disease can be checked and a healthy growth re-established by the simple process of cutting. This should be the rule whenever alfalfa, young or old, begins to show leaf-spot abundantly, and when the trouble is rapidly spreading towards the upper leaves it is best to cut at once. If the field is newly sown, and the crop only a few inches high, the cutting should not be too close to the ground. What is cut may be allowed to lie where it falls. Should the growth which follows in turn become infected, the trouble should be met in the same way, that is, the alfalfa should be recut.

In the case of an established field of alfalfa, if leaf-spot has become abundant the crop had best be cut and fed, or made into hay at once, even although the alfalfa may not have come into bloom.

HARVESTING ALFALFA.

Alfalfa should usually be cut while in early bloom. If the stems close to the root be examined at this time it will be found that they carry buds which are beginning to develop. This indicates that it is ready to make a second crop. If allowed to stand much beyond the period of early bloom the plants start much less promptly after being cut, and the total yield of the season will be relatively small.

The last cutting in any season should not be too late. It is desirable that there should be a considerable growth remaining on the field for winter protection.

Alfalfa may sometimes, with advantage, be fed green; it has been successfully ensiled, but, as is the case with other legumes, the resulting silage is strong in flavor and not wholly satisfactory. It is preferable in most cases to make the crop into hay.

After cutting, alfalfa should be allowed to lie, with possibly one turning, until it is wilted. It should then be put into windrows and then into cocks, where it should be allowed to remain until cured. Hay caps are very desirable; indeed, almost a necessity for entirely satisfactory results. The length of time which alfalfa must remain in the cock will vary greatly with the weather. If this is showery or rainy it of course cures

slowly, in which case, in order to avoid injury to the plants below, the cocks should be moved. It is desirable, as in the case of clover, which is often similarly handled, to remove the caps and open and turn over the cocks on the morning of a good day, when it is judged to be sufficiently cured to be put in.

TOP-DRESSING ALFALFA.

If the crop has been successfully inoculated, and the nodules which have been referred to are abundant on the feeding root-lets of the plants, it is not ordinarily necessary to top-dress with materials furnishing nitrogen; or at least, if such materials are at all required, as may be the case upon soils which are naturally very poor and light, they should be used only in moderate quantities.

Top-dressing with manure cannot as a rule be recommended, for this will increase the tendency of grasses and clovers to come in. It is better to depend upon chemical fertilizers, and in order to secure large crops for a series of years the more important mineral elements of plant food must be supplied in abundance. The following mixture of materials is recommended, per acre, annually:—

	Pounds.
Basis slag meal,	1,200 to 1,500
High-grade sulfate of potash,	250 to 350

Or, in place of the latter, low-grade sulfate of potash, 500 to 700 pounds. This mixture may be applied either in the autumn or in very early spring.

SECONDARY VALUE OF ALFALFA.

Alfalfa, when successful, as has been pointed out, is not only a valuable forage crop, furnishing large yields of highly nutritious forage in proportion to area, but is also a crop of much importance because its introduction will mean much improvement in the soils on which it is grown. Wherever alfalfa is successfully cultivated the soils are sure to be rendered more productive. This improvement is a consequence, first, of the

deep sub-soiling due to the penetration of the great tap roots of the plant; and second, to the accumulation of nitrogen in the roots and stubble, drawn in the first instance from the air. It will be understood that when an alfalfa sod is plowed, and the roots and stubble decay, the large amount of nitrogen which they contain becomes available to succeeding crops.

EXPERIMENTS RELATING TO THE PREVENTION OF THE CLOGGING OF DRAIN TILE BY ROOTS.

BY G. E. STONE AND G. H. CHAPMAN.

For the past three years experiments have been carried on in our conservatory for the purpose of studying the effects which various antiseptic substances would have in preventing roots of different kinds from entering drain tile. The clogging of drain tile by roots is a serious matter, many drains being rendered useless in a short time. The only remedy in such cases is to dig up the tile, clean it out and lay it over again. This is expensive and unsatisfactory in any case, particularly so with sewer pipes or the drainage tile under steam-heating conduits.

Our experiments were carried on in different ways. In one series we buried 3-inch Akron tile vertically in boxes containing soil. The lower ends of these tile were cemented and the tile filled with water to the joints. The joints were then calked with various antiseptically treated fibers, and the antiseptic substances with which the joints were treated proved quite effective in preventing the access of roots to the tile.

Another method consisted in growing various plants in small pots, the bottoms of which were filled with chemically treated fibers. The pots were then filled with soil and planted with different seeds. It is well known that plants when grown in small pots soon fill the soil with roots, which seek new sources of supply by passing through the hole at the bottom of the pots. Our experiments were arranged in such a way that the roots, in order to accomplish this, would have to pass through or around the chemically treated fibers, and the ability of these fibers to prevent root development constitutes a test of their efficiency. This method proved quite satisfactory. After a

year or two trial of the above method we devised another, which has also proved to be very satisfactory. This consisted in growing plants in boxes, the bottoms of which were covered with wire netting. Over the wire there was spread about an inch of variously treated or untreated fibers, as some checks were left in these experiments. The boxes were then filled with soil in which various plants were grown. They were placed over large trays filled with water, a space being left between the bottom of the wire and the surface of the water for the purpose of observing the roots. The object of this test, as before, was to determine what substances would prevent roots from penetrating into the water below.

RESULTS OF POT EXPERIMENTS.

These experiments were started in the spring of 1908 and were conducted along the lines previously described; that is differently treated fibers were packed into the bottom of common flower pots for the purpose of determining what effect they would have on root penetration.

About 1 inch of the fiber was packed in 4-inch pots. In some of the pots the fiber was packed rather tightly and in others laid in loosely. On top of the fiber were placed 3 or 4 inches of soil and clover and grass seed sown; in some cases willow cuttings and other plants were also used. Several series of pot experiments were conducted. In all cases the pots were placed in saucers or in galvanized iron trays containing about half an inch of water, although the pots were watered occasionally from the top.

The substances used in these pot experiments and the treatment given are as follows:—

- Excelsior and creosote.
- Excelsior and Carbolineum.
- Sawdust and creosote.
- Sawdust and Carbolineum.
- Asbestos and creosote.
- Asbestos and Carbolineum.
- Asbestos and arsenate of soda.
- Oakum and creosote.
- Oakum untreated.
- Cocoa fiber and creosote.

The excelsior was the ordinary kind used for packing, and when boiled with creosote absorbed it very readily. A coarse sawdust, principally pine, was used in these experiments. Ordinary asbestos fiber was used, and the oakum came in large masses, and was the same as that used by plumbers in calking joints. Cocoa fiber is a refuse product from the manufacture of fiber mats, and was obtained from the Heywood Manufacturing Company, Boston. It has occasionally been recommended for mulching plants. In all cases these fibers were boiled for a long time in creosote or whatever medium was used. They were then air dried before using. The excelsior before being used was chopped up into a finer condition, so that it would pack more closely in the pots. The cocoa fiber and the asbestos did not take the creosote to any great extent, both being practically failures in this respect, and the oakum did not take it as well as the sawdust and the excelsior, which proved to be the best in this respect.

The results of this series of experiments in pots may be summarized as follows:—

The untreated oakum had no appreciable effect in checking root development, the roots growing unharmed in the oakum and penetrating through the bottom of the pots into the water below.

The oakum treated with creosote did not entirely prevent the roots from passing through the oakum to the bottom of the pot. Many of the roots, however, were browned and dead where they came in contact with the treated oakum. The nature of the oakum was such that a less degree of compactness was maintained than in any other of the substances.

Asbestos treated with arsenate of soda had no appreciable effect, the roots penetrating the treated fibers freely, due undoubtedly to the solubility of this compound in water.

The asbestos and creosote treatment was more effective, and few if any roots extended through the pots, although there was a healthy root development extending for some distance into the fiber.

Cocoa fiber treated with creosote did not prevent root development to any great extent, the roots penetrating freely unharmed through the bottom of the pot.

Sawdust treated with creosote proved to be one of the best substances for checking the development of the roots. In all but a few cases the roots in direct contact with the sawdust were killed, although in one instance, where the sawdust was not compacted enough, one root developed along the side of the pot without being injured. Where the sawdust was well compacted in the pots all the roots which came into contact with it were killed.

The excelsior and creosote were fully as effective as the sawdust. The excelsior, however, being more loosely compacted, allowed some roots to penetrate further into it before being killed than was the case with the sawdust, but in no case did any of the roots penetrate through or around the excelsior through the hole in the bottom of the pot.

Not quite as good results were obtained from the use of excelsior and Carbolineum and sawdust and Carbolineum as with excelsior and creosote and sawdust and creosote. Both the excelsior and sawdust retained the creosote the best, as was evident from the color and odor as well as from the results of root killing and penetration. A greater compactness of both the sawdust and excelsior would undoubtedly prove even more effectual in preventing root growth.

The substances, arranged as regards their degree of efficiency, may be grouped as follows:—

- Excelsior and creosote.
- Sawdust and creosote.
- Excelsior and Carbolineum.
- Sawdust and Carbolineum.
- Cocoa fiber and creosote.
- Asbestos and creosote.
- Oakum and creosote.

The sodium arsenate treatments were all failures, as this substance seemed to wash out very quickly, and in one case, where asbestos was treated with creosote, 40 per cent. of the roots passed through the hole in the bottom of the pot.

No better results were obtained with asbestos and Carbolineum.

Cocoa fiber failed to absorb and retain the chemicals any

length of time. For this reason it was unsatisfactory. However, in some experiments a large percentage of roots were killed when they came in contact with this substance, especially when the creosote was retained by the fibers.

The creosoted and untreated oakum did not prove of much value.

There was little difference between the excelsior and sawdust treatment; one was about as good as the other, although the excelsior was easier to manipulate. On the other hand, the sawdust was more compact, and this was in its favor. Creosote in these tests appeared to be slightly superior to Carbolineum, but the latter would be an excellent substance for this purpose.

EXPERIMENTS IN BOXES.

A. — Experiments in boxes provided with vertical tile, with one end plugged, have been carried on for two years. In these boxes were grown tomatoes, grass and willows. The boxes were 14 by 14 by 14 inches, and contained about 1 foot of soil. A vertical 3-inch Akron tile extended to the bottom of the boxes, the joints being 4 inches below the surface of the soil. The bottoms of the tile were plugged with cement and the tile was kept filled with water to the level of the joints. One tile was placed in the middle of each of the four boxes, the joints being treated with the following substances: —

Sawdust and creosote.

Excelsior and creosote.

Cocoa fiber and creosote.

Oakum untreated.

The results of this experiment are as follows: —

The treated sawdust prevented any roots from penetrating the tile, and when there was any attempt made to penetrate the treated substance, the roots turned brown and died.

The creosoted sawdust appeared as good as when first applied, and was characterized by a strong creosote odor.

The results of treatment with excelsior and creosote were practically the same as those with sawdust. In a few cases, however, roots forced their way along the tile to the joint. The

roots which attempted to grow in excelsior were browned and dead. The results obtained from the use of cocoa fiber and creosote were not nearly as good as the two preceding ones. The roots penetrated the fiber and came through into the water. About 35 per cent. of the roots which penetrated the fiber were alive and healthy.

The results obtained from the untreated oakum showed that it had little effect, the roots appearing to be healthy, and not at all injured by this substance.

B. — The experiments described here were made in three boxes, each being 14 inches wide, 22 inches long and 14 inches high. The bottoms of these boxes were covered with $\frac{1}{4}$ -inch mesh galvanized wire. On each wire in one-half of each box there was placed about 1 inch of sphagnum, the other half being covered with some treated material. Box No. 1 had sphagnum 1 inch thick in one end and the same amount of excelsior treated with creosote in the other end. Box No. 2 was likewise provided with untreated sphagnum in one end, the other being filled with sawdust treated with cement. Box No. 3 was treated in the same way as No. 1. These boxes contained about 12 inches of soil, and rested on galvanized-iron trays containing 2 inches of water. A space of about half an inch, however, was left between the bottom of each box and the water in the tray for the purpose of observing the roots. Several crops of tomato and tobacco plants and grass were grown in these boxes, with the results that none of the roots had penetrated through the treated substances into the water in the tray, whereas in every case where untreated sphagnum was employed the root penetration was invariably common.

The results obtained from these various methods of treatment show that it is possible at the present time to prevent root growth by the use of certain chemical substances. Our results seem to indicate, also, that these various treatments possess a lasting effect, and that chemically treated fibers could be used in a practical way to prevent the clogging of drain tile. In these experiments it must be borne in mind that a vast number of roots come in contact with the treated substances, and that ordinarily if these substances had not been there thousands of roots

would have developed and occupied the space given up to the treated fibers; and probably in all cases a large number of the roots would have penetrated through the bottom of the pots into the water below. In only a very few instances did any of the roots in the experiments where creosote was used penetrate to any depth where sawdust and excelsior were used. Practically all the penetration occurred close to the surface of the pot, where the chemically treated fibers were packed rather loosely, and especially in those experiments where excelsior was used.

A more or less thorough calking of the joints of Akron tile with either creosoted excelsior or sawdust would undoubtedly prevent the occurrence of roots in the joints, and consequently in the tile itself. Some sewer pipes have been calked with these chemically treated fibers, but it is as yet too early to state how effectually they may have accomplished their purpose. Akron tiles, or those provided with flanges, are best adapted to treatment. Ordinary land drain tiles, however, are not provided with flanges, and it is a question whether root penetration could be successfully prevented by using these fibers, at least by placing them loosely over the joints. It would be possible and no doubt practicable, however, to clamp masses of treated asbestos or excelsior around the joints of ordinary land tile, which would prove effective. Such clamps could be constructed from heavy galvanized wire, so as to hold the excelsior very firmly around the joint, and at the same time not affect materially the inflow of drainage water. It would be possible, also, to make use of small sections of tile of larger diameter (collars), which could be placed over each joint and the treated fibers packed in tightly around the joints.

Creosote appears to be the best substance with which we have experimented, since it is not only one of the best preservatives, but possesses excellent toxic properties. No doubt there are other fibers than those which we have used, and there are many substances which possess properties toxic to roots, such as tannin, etc.; but many others, like sodium arsenate, wash out quickly and lose their effectiveness in a short time.

From the results of these experiments it would appear that chemically treated fibers would undoubtedly remain for many

years in the soil without serious deterioration, and if this treatment would succeed in doubling or trebling the usefulness of drain tile, it would be well worth while to employ it.

There is also the possibility of killing roots in tile by treatment with chemicals or gases, but little or no attention has been given to this phase of the subject.

Further experiments are being made along this line, and in the mean time it is hoped that more extensive and practical tests can be arranged.

THE CLOGGING OF DRAIN TILE BY ROOTS.

BY G. E. STONE.

Quite frequently trouble is experienced from roots of various trees entering drain tile, sewers, etc., and this often causes much vexation, labor and expense. The Carolina poplar, which is often planted as a shade tree in cities, frequently becomes a nuisance in consequence of its peculiar habit of working its roots through the joints of tile used for sewerage, etc. It is a comparatively easy matter for roots to gain entrance into the uncemented joints of tile, and even when tile is cemented they often manage to crowd in and fill the tile with a mass of roots which eventually clog it and render it useless. Instances are known of roots penetrating even sewers constructed of brick and cement. The roots of other trees besides Carolina poplars are known to be offenders in this respect. Willows, elms, etc., are responsible for considerable clogging of tile drains. There are also many instances even of fungi and algæ clogging up small drains. The writer some years ago had called to his attention a case where *Oscillaria*, one of the blue-green algæ, was constantly clogging tile, much to the annoyance of the landowner. On the Massachusetts Agricultural College grounds they have experienced much trouble with roots of various kinds clogging sewer pipes, and the drain tiles located under the steam pipes leading from the central heating system to the various buildings have become clogged.

In the case of the sewer tile referred to the joints were cemented with Portland cement, nevertheless, the roots gained entrance here and there through some of the joints, and in a short time they developed so profusely as to clog the tile, with the result that it had to be dug up and repaired. The joints of the 6-inch Akron tile underlying the steam-heating pipes are not cemented, and are located 5 feet or more below the surface. In two or three years after the tiles were laid some of them had

become clogged with the roots of elm trees. This clogging prevented the water from flowing through the tile, and caused a dam, as it were, resulting in the water flowing back into the conduit and flooding the steam pipes. A stream of cold water flooding steam pipes is not conducive to the best results, since it causes condensation and a decrease in the temperature of the steam. It is necessary, of course, to leave the joints of Akron tile open when used for the purpose of draining the conduit trench of a central heating and distributing plant, since these pipes must take off the water from the trench and prevent it from coming into contact with the steam pipes in the conduit. As long as the joints remain open it is with great difficulty that the roots of trees, etc., are kept from growing in the tile, and sooner or later it is made ineffective. Tree roots will penetrate tile protected with carefully cemented joints, and become a nuisance, as is shown by the following letter. In the city of Newark, N. J., the Shade Tree Commission has been requested by the department of sewers and drainage to omit the planting of Carolina poplars on streets since the roots of these trees proved to be a nuisance to drains, and the Shade Tree Commission has decided to plant trees which are less of a nuisance in this respect on the streets of Newark in the future. At my request Mr. Carl B. Bannwart, secretary of the Shade Tree Commission, Newark, secured this statement from Edward S. Rankin, engineer of sewers and drainage of the city of Newark:—

Replying to your letter of the 20th inst., we find that the roots go through the joints of tile pipe even when carefully cemented, and the trouble seems to be increasing. In 1909 we had 15 stoppages caused by roots; for the first eleven months of 1910, 23, of which 5 occurred in the month of November. These stoppages were all in house connections, and in addition to these we have also had a number of cases in our main pipe sewers. The roots after penetrating the pipe seem to spread out and practically fill the whole pipe. I have no way of knowing how long a time it takes for these roots to grow. To the best of my knowledge we have had no trouble with any of our brick sewers. The trouble seems to have been caused in all cases by poplar trees.

There recently came to our attention, through Mr. C. N. Minott, field superintendent on the gypsy and brown-tail moth work, a notable case where the small root from a pear tree had

gained entrance to a drain tile. This tile was 12 inches in diameter, and was laid about seven years ago to take the seepage waters from a reservoir located in the town of Belmont, Mass. This pipe passed through land owned by the Hittinger Brothers of Belmont, well-known and extensive market gardeners, and part of it passed near a pear orchard. There was a constant flow of water through this tile summer and winter, but the pipe was never full. At the time the tile was laid the joints were not cemented, and of course there was an excellent opportunity for roots of various kinds, if so disposed, to penetrate the joints of the pipes and secure an abundant supply of water. During November, 1909, about seven years after the drain pipes were installed, it became necessary to dig up a large part of them on account of their inefficiency and replace them. It was found on digging up this tile that it was badly congested by profuse root growth. A careful examination of the location showed that this growth of roots originated from a single off-shoot of a pear tree located some 7 feet away. This enormous mass of pear roots was removed from the tile and carefully laid aside, and we gladly accepted Mr. Minott's offer to present this to our museum. Mr. Minott later packed and shipped this to us, at the same time furnishing us full data concerning it. This mass of roots was found to measure 61 feet in length. Only a single root entered the tile, it having a diameter of about $\frac{1}{2}$ or $\frac{5}{8}$ of an inch. This root, when it entered the tile, immediately subdivided into innumerable rootlets, and these were again divided into countless smaller roots. At the time the tile was dug up and the roots removed the drain had been in operation seven years, although a cross-section of the root, together with an examination of the annular rings, where it entered the tile, showed that it was only five years old. Therefore it took only five years for this mass of roots to clog up a 12-inch tile.

The maximum diameter of these roots in the dry state is 6 or 7 inches, but when alive and flourishing in the tile their diameter exceeded this. The roots as they reached the laboratory had a decidedly bad odor, showing that if no sewage were present in the tile there was certainly a considerable amount of organic matter in the seepage, derived from the soil or some other source, which proved of value as plant food. Soon after the

specimens arrived at this laboratory they were spread out on the floor and measured. This was done by Mr. R. D. Whitmarsh, and was accomplished by laying out on the floor sections 5 feet in length. The number of roots in each 5-foot section was counted. This was multiplied by the length of the section and the whole tabulated (see table). The mass of roots was just 61 feet long, and the total length is 8,498 feet, equal to 1.61 miles in length. Adding to this the numerous small roots, which range from a few to several inches in length, and which were disregarded in our section count, the total length was estimated to be over 2 miles. This enormous development from a single root of a pear tree located 7 feet away is greatly in excess of what would take place if the roots were in the soil, since the conditions of the drain tile stimulate root development very materially. However, the root system of any tree or shrub is far in excess in length and area of what the layman imagines. The profuse growth of roots in water is also seen in cases where old wells become filled with root growth, but the pear tree root in question is one of the best examples which has ever come to our notice of root development in drain tile.

Table showing the Growth of Pear Tree Roots in Drain Tile.

NUMBER OF SECTION.	Length of Section (Feet).	Number of Roots in Section.	Length of Roots in Section (Feet).
1,	5	34	170
2,	5	41	205
3,	5	73	365
4,	5	153	765
5,	5	199	995
6,	5	313	1,565
7,	5	373	1,865
8,	5	447	2,235
9,	5	141	705
10,	5	53	265
11,	5	31	155
12,	5	36	180
13,	1	28	28
Total,	61	-	8,498

THE SPRAYING OF TREES.

BY G. E. STONE.

The great value and economic importance of spraying shade and fruit trees have resulted in placing on the market a large variety of fungicides and insecticides and types of machinery. Massachusetts has unfortunately been obliged to spend more money in spraying than any other State, and many towns and cities in the eastern part of the State, where the brown-tail and gypsy moths are so prevalent, spend thousands of dollars yearly in spraying.

Besides the larger spraying enterprises which are being carried on under the supervision of the Gypsy and Brown-tail Moth Commission, much private work is being done, and hundreds of tons of arsenate of lead are used annually in this work. While the above-named pests have not at present invaded the center and western part of the State to any extent, the presence of other pests necessitates spraying our shade trees.

The question of economical spraying on a large scale is an important one, and for a long time there has been a need for more efficient and cheaper methods. The writer, who has for many years had experience as tree warden, has had unusual opportunities to observe the work being done along this line in Massachusetts, and has felt the great necessity for improvements in the methods of spraying. It has often been a question whether our towns and cities can afford to use the methods which are recommended and practiced by the best orchardists for shade trees. The aim of the orchardists is to cover every part of the tree which needs protection with a very fine mist spray. This method cannot be too closely followed by orchardists, since it is not necessarily expensive when only orchard trees and small fruits and crops such as potatoes are concerned. When how-

ever, we have to spray large elms, the question is an entirely different one.

A few years ago some large elms located in the public square in one of our cities were sprayed by the same methods used by the best orchardists, at an expense of something like \$16 per tree. These trees, to be sure, were unusually large, but the cost was so great that in our opinion it set a limit to the amount of spraying which should be undertaken by such methods. Most of the former spraying of shade trees was done by this very expensive method at a cost of \$1.50 upwards for trees 14 to 18 inches in diameter. In much of this early spraying the Vermorel, Ware or similar fine spray nozzles on poles were used, and spraying had to be done at close range for the best results. The early gypsy moth work was done in this same way, any other method at that time being considered useless. This method entailed a great deal of climbing on the part of the sprayers, and was a slow and costly process.

Some years ago the Gypsy Moth Commission abandoned these fine nozzles and close-range methods of spraying, and now employs large nozzles and large hose, and exceptionally high pressure is obtained from powerful machine sprayers. With the larger area which has to be treated at the present day the older method would not only prove prohibitory on account of the expense, but also because of the time involved. Practically all the spraying with these large modern machines is done from the ground, doing away with the necessity for ladders and for climbing trees; and by the use of one or more long lengths of hose large areas can be treated from one spot. This method of spraying trees is very effective and very much cheaper, the average cost of spraying woodlands being something like \$12 or less per acre. With this method the spraying mixture is delivered to the nozzle through a large strong hose under a pressure of 200 to 250 pounds, the high pressure breaking the spray up into a fine mist. The spray has considerable spread when broken up, which is a desirable feature in treating woodlands and country roadsides, but on this account it is more or less objectionable for use on residential streets in cities and towns, as it is likely to dis-

figure anything it touches. The writer has been of the opinion, however, for some time, that the high-pressure, large-nozzle equipments are the cheapest and most practical for shade-tree work.

What might be termed a compromise between the fine-nozzle system and the high-pressure, coarse-nozzle system employed in the gypsy moth work is often used in spraying shade trees at the present day. This consists in the use of the Bordeaux nozzle, which has an aperture of $\frac{3}{32}$ of an inch. When used on a hand pump with a pressure of from 50 to 70 pounds, or even more, it does not give, in our estimation, a satisfactory spray. Where a small number of trees are to be sprayed, and where an expensive equipment cannot be afforded, small hand pumps will do the work, but when it becomes necessary to spray 500 or 1,000 trees in the course of a few weeks, power sprayers are necessary and more economical.

The most important factors necessary for economical work in spraying shade trees on a large scale are machines powerful enough to maintain a constantly high pressure; an efficient nozzle, and competent men to do the work. By high pressure we mean a pressure of 200 to 250 pounds, preferably the latter. This should be maintained constantly, and the capacity should be sufficient to maintain this pressure in a 1-inch delivery hose, if necessary.

In our work on spraying shade trees we endeavor to have a 1-inch aperture from the pump to the nozzle, care being taken to have no reducing valves or couplings anywhere on the line to reduce the volume of the spray, since it is better to have a good flow of the spraying mixture directly to the nozzle.

Too much attention cannot be given to the nozzle. It should be adapted to the work required of it, and a satisfactory nozzle is worth almost any price. It should be constructed on mechanical principles which will enable it to break up the spraying mixture into as fine a mist as possible, and to do this at a distance convenient for the economical application of the spray. The ideal nozzle for the economical spraying of trees either from the ground or a ladder should possess some carrying fea-

tures, and still break the spray up finely. The nozzle should not be encumbered, any more than the hose, with worthless mechanical devices which produce friction without adding anything to its efficiency, and for this reason we believe that it is better to employ mechanical devices to break up the spray after it has left the nozzle rather than in the nozzle itself. This applies, of course, to that type of nozzle intended to be used with high pressure, either from the ground or from a ladder, since in this case it is necessary for us to have nozzles adapted to throw a certain distance in order to reach the foliage, and have it broken up into as fine a mist as possible. This does not apply to types of nozzles like the Vermorel and Friend, which are well adapted to the purposes for which they are intended.

The question of competent men and good machinery is also important in spraying. Any good reliable man of common sense can learn to spray in a short time, and there should be little difficulty in securing such men if they are treated properly and well paid.

As regards spraying outfits, there is still a chance for improvement in many ways. There are, however, many good power sprayers on the market. The New Leader spraying machine, made by the Field Force Pump Company of Elmira, N. Y., of which there are several in use in the Connecticut valley, has proved to be satisfactory. This is provided with a $3\frac{1}{2}$ horsepower engine, and is one of the cheapest and best machines on the market. A machine of this type, while not so thoroughly constructed in some respects as the larger and more expensive machines, is capable of doing good work for some years. The type of machines which depend upon charging with carbonic acid gas for their power we consider failures for any kind of work, since the pressure is never constant, and much of the time is too low for any kind of spraying. The company which manufactures these has recently constructed a machine in which the power is compressed air instead of gas. This air is constantly pumped and pressed into large cylinders, which are attached to the truck. One of the difficulties in a machine of this type for high-pressure work consists in the use of very heavy

cylinders, which, on account of the weight, must have a limited capacity for storing the air. There are on the market many good hand pumps which will maintain a pressure of 50 to 70 pounds with an ordinary nozzle, and these may be purchased for \$12 to \$20. For general purposes they are the cheapest and most satisfactory spraying devices produced at the present time.

SHADE TREE TROUBLES.

BY G. E. STONE.

If the amount of correspondence is any criterion of what people are interested in it might be inferred that the citizens of Massachusetts place a high value on shade trees, and we are receiving an ever-increasing number of such inquiries. Such organizations as civic leagues, village improvement associations, the Massachusetts Forestry Association and the different horticultural societies are very largely responsible for this awakened interest in the subject of shade trees, although landscape gardeners and highway and park commissions have had no small influence in this direction.

Shade trees have enough to contend with ordinarily, but the extreme climatic conditions which have prevailed during the past few years have been an additional burden on them. The more extensive use of telephones, electric lights, trolley transportation, gas, sewers, aqueduct water, etc., made necessary by modern conditions, has been hard for our shade trees, and the severe winterkilling of roots, which occurred a few years ago, has been responsible for the death of thousands. Many trees which were not so seriously injured a few years ago as to die outright were left to a lingering existence, and many of them are constantly deteriorating and in a few years will be dead. The trees which have shown this slow dying back of the root system most prominently, and which later completely collapse, are the elm, red maple, black and white ash, and, to a less extent, the rock maple. The writer has had opportunity to observe the condition of a large number of these trees each year and the effect which root killing has had upon them. Many large elms, which a few years ago were in perfect condition, may be seen slowly dying from the effects of severe climatic conditions, and

many of them gave promise of living at least one hundred years in favorable environments. The black and white oak, ash and red maple are dying more rapidly than the elm. The European birch, so commonly used for ornamental purposes, has been dying everywhere this past summer from the effects of borers, and possibly the extreme drought.

The past summer the writer has had an opportunity to examine many black oaks along country roadsides, where the conditions for tree growth would be considered fairly good. These trees are located in different towns in the eastern part of the State, where the oak seems to be affected the most severely. Near one estate, where 19 black oaks (*Quercus velutina*, Lam.) were examined, the larger part of them were found to show evidence of root killing. These trees are located on a slight embankment, and that part of the root system nearest the road was invariably affected the worst. The trees showed various degrees of root killing, some of it being so far advanced that 75 per cent. or more of the tissues of the trunk were dead on the roadside. Some of the trees were in fairly good foliage, others had lost a little foliage, and many had considerable dead wood, the amount corresponding to the condition of the roots. On another roadside, where the conditions were somewhat similar, although in a different town, the same root killing was observed. In this locality there were 50 or more black oaks, many with scarcely any live limbs, and supporting only from 1 to 20 per cent. of the original foliage. An examination of these trees showed the trunks to be perfectly sound, and even the larger roots at the base of the tree were alive. When the soil was removed from the roots for a distance of 3 or 4 feet it was found, however, that practically the whole root system had collapsed, and conditions showed that there had been a slow but constant dying back of the roots for the last five or six years. For example, roots $\frac{1}{4}$ inch in diameter, which normally would extend 15 to 25 feet from the base of the tree, had died back to within 3 to 6 feet from the base. It could be plainly seen that the trees had made strenuous efforts to recover their root systems by repeatedly throwing out a profuse growth of side roots, but as the affected roots were continually dying back, the new laterals were of little or no use,

as they would die in turn. Had it been possible to prune these roots, their dying back could have been checked, a new system of secondary roots would have formed and the tree would have recovered. Oak trees in this condition have been fairly common in certain parts of eastern Massachusetts for the past few years, and many more will show the same symptoms later.

Another trouble which has been more or less common the last few years is known as sun scald of maples. This is responsible for injuring many valuable shade trees. On one avenue we recently observed 16 rock maples killed by sun scald. This affects the trunks and limbs on the side of the tree exposed to the sun. It is characterized by a drying up of the bark, which almost immediately becomes affected with a canker fungus (*Nectria cinnabarina*, Fr.). On smaller trees sun scald often kills the whole trunk. Generally only one side of the tree is affected, and occasionally one or more branches. The root system is not affected by sun scald, and limbs are much less likely to be affected than the trunk. The fact that the root system is not affected by sun scald, and that the bark usually becomes infected with *Nectria*, makes it easy to distinguish this type of injury from that caused by gas poisoning, since in this case the *Nectria* never appears, but, instead, profuse growths of *Schizophyllum* and *Polysticta* are present. Very similar effects are produced on the trunk when the tree is sprayed with kerosene or crude oils, since *Nectria* almost always accompanies such injury.

Sun scorch differs from sun scald very materially, as it affects only the foliage. This is very common on maples, and in recent years the white pine has been affected in this State. Sun scorch follows dry periods, and is usually associated with strong, drying winds, lack of water in the soil, etc.; in fact, it may be caused by various abnormal functions of the root system. It hardly ever completely defoliates trees, and on maples it simply burns the foliage, particularly on the windward side. Various conifers, such as arbor vitæ, when grown in dry soil invariably show sun scorch in the spring, particularly when there are drying winds and the ground is frozen. For many years past we have received a large number of inquiries concerning the effects of sun scorch on maples. These effects resemble those of leaf

blight (*Glæosporium*), and various atmospheric gases, or illuminating gas, escaping into the soil, often cause effects resembling those produced by sun scorch. Severe injury is caused especially by the illuminating gas. Under ordinary conditions trees seldom recover when once poisoned by this gas. It is possible, however, in certain cases of gas poisoning, especially in the incipient stage, to amputate certain roots at the base of the trunk, which prevents the further translocation of the poisonous substances and often saves the tree.

Every tree which dies along the roadside, however, is not necessarily killed by gas or electricity, notwithstanding the fact that this seems to be a popular belief. It should be said that the public service corporations of Massachusetts, on the whole, take a very sensible and unbiased view of the claims for gas injury, and if the people would meet them in this same spirit adjustments of legitimate claims for damages would no doubt be satisfactorily made in practically every case.

THE CHESTNUT DISEASE (DIAPORTHE PARASITICA).

BY G. E. STONE.

The chestnut disease, which has wrought such destruction in the vicinity of New York since 1904, has been observed quite extensively in some parts of our State the past summer (1910). Occasional reports of the disease occurring here and there have been received for three or four years, but such reports, when investigated, proved to be groundless. Whenever a chestnut tree in a more or less unhealthy condition has been observed, the cause of the trouble has promptly been put down as chestnut disease. It is possible that the chestnut disease has been present in Massachusetts for three or four years, but it has not been called to our attention, neither has any systematic attempt been made on our part to locate it.

It has been reported by J. F. Collins in Rhode Island, and he has traced it over the Rhode Island line into Massachusetts. The territory which appears to be most severely affected in this State is the Connecticut valley, where the disease may be seen over quite an extensive area. Mr. Sumner C. Brooks went over a considerable territory this past summer and reported several hundred trees affected. Some of them appear to have been dying for three or four years, according to the best information we are able to obtain, and some of the injury may date back even further than that. The disease exists, no doubt, in other parts of the State, although little has been found at the present time. From a more or less hasty survey of the State, made by this department last summer and fall, together with correspondence and inquiries, we were able to discover little, if any, of the disease outside of the Connecticut valley region. As in the case

of the elm-leaf beetle and other pests, the disease seemed to be more common at first in the Connecticut valley.

The writer has been informed by one who has had some opportunity to observe this disease that it appears to be less prevalent on high elevations than in the valleys. This opinion is, of course, based on merely casual observations. Whether there is really any distinct difference between valleys and high elevations as regards the prevalence of this disease would be interesting to observe. If this were the case, one might expect to find the disease most commonly in the valleys, like the Connecticut, Blackstone, Housatonic, etc., in this State. It is, however, quite significant that the Connecticut valley region should possess such a large amount of infection as compared with other sections. We have noticed for some time that there is a difference in the degree of winterkilling occurring in valleys and high elevations in this State. By far a greater amount of winterkilling of trees occurred in river valleys and on the lower elevations during the severe winter of 1903-04 than on the higher elevations, the Connecticut valley being especially notable in this respect. It is, moreover, a significant coincidence that the chestnut disease should make its appearance at about the same time that vegetation was so severely injured by the severe cold which occurred during the winter of 1903-04 all over the northeastern part of the United States.

Our observations on the effects of meteorological conditions on vegetation, and the unusual opportunities we have had to study shade-tree conditions for some years, have brought to our attention the unusually large amount of dead wood found on chestnut trees the past four or five years. From what we have seen of the chestnut during this period we are of the opinion that it has not been in the best condition during late years, and that the chestnut, like the native white and black oaks, elm, red and rock maples, ash, etc., has been more or less affected by the severe cold and drought of late years. It is intended during the coming year that a more serious and thorough investigation of the cause and distribution of the chestnut disease be made in this State. In the meanwhile it is essential that lumbermen cut off their diseased trees and make use of them now.

CROWN GALL.

BY G. E. STONE.

For many years a disease known as crown gall has affected raspberries in this State. The disease is characterized by large abnormal swellings or gall formations near the crown of the roots, and is well known to all raspberry growers. Raspberry plantations are almost invariably affected with crown gall after being set out for a few years, and in the course of time these galls affect the plant to such an extent that the crop is no longer profitable, and it becomes necessary to start a new plantation. In recent years other plants have become affected with crown gall, which is becoming more common on the roots of our fruit trees, notably the apple, pear and peach, although until five or six years ago galls on fruit trees were very rare in Massachusetts; at least, if they existed at all they were limited to certain areas, and were brought into the State on infected nursery stock.

It is quite certain that the germs of crown gall are not indigenous to our soil, and in all cases the disease has been introduced through nursery stock from outside the State. Apple trees have been grown in the State for years without being affected, and it is reasonable to suppose that they may be grown to-day in most of our soil without infection, providing clean stock is secured when planting an orchard. However, when crown gall is once introduced into an orchard it is difficult to prevent even clean stock from becoming infected. The writer knows of a large tract of land, which was, until three years ago, free from crown gall, where to-day it is impossible to plant even seedlings without their becoming infected. The soil in this instance was first infected by imported stock; and undoubtedly by the use of cultivators, etc., the disease germs have been spread over a large part of the cultivated area. The organism causing

the galls is, according to Smith and Townsend,¹ a species of bacillus; and, if true, this would explain the readiness with which the disease spreads and infects heretofore uninfected areas. It appears to be doubtful, however, whether the organism causing crown gall of the raspberry is identical with that causing the galls on the apple, at least in this territory, since raspberries have been affected for many years in this State, and fruit trees only recently; moreover, raspberries have been grown for years in close proximity to fruit trees in all stages of development without the slightest evidence of gall infection.

Unusual interest is now being shown in fruit growing in this State, and the appearance of a disease of this nature must be given consideration. Considerable difference of opinion exists in regard to the effect crown gall may have upon a tree, and there is still much to be learned in regard to the seriousness of this trouble. Some authorities claim that crown gall does no harm whatsoever, while others give alarming accounts of the serious damage it causes. It would appear, however, that crown gall is less to be dreaded in New England than in some other sections of the United States. This is the opinion of F. C. Stewart of the Geneva Agricultural Experiment Station, Geneva, N. Y., who has had unusual opportunities to observe crown gall in the New York orchards and nurseries. The most intelligent orchardists, however, prefer stock free from the disease, and most of them refuse to accept contaminated stock from a nursery firm. A very large amount of infected nursery stock has, however, undoubtedly been shipped into this State and planted without the buyer knowing that it was affected.

We have had many opportunities recently to observe crown gall on apple, pear and peach trees, and in some cases on the Carolina poplar, but we have seen only one or two instances where trees have been so badly affected that they have died from the effects of the disease. Much affected stock has been thrown away and burned, not being considered suitable to place on the market. Crown gall on fruit tree stock has become so general in nurseries at the present time that one large concern has found it practically impossible to obtain stock free from it, and this

¹ E. F. Smith and C. O. Townsend, *Science*, n. s., Vol. 25, April, 1907, pp. 671-673, also Vol. 30, No. 763, Aug. 13, 1909, p. 223.

firm is in a quandary as to what to do. When one has a young orchard with 50 per cent. or more of the trees affected, the question arises as to what should be done with it. It is possible, also, that one might obtain stock from a nursery free from galls, yet the soil from which they were taken may have been contaminated, and in this way the disease might break out later, when the stock was transplanted. Even though it is not certain that crown gall on fruit trees is of serious consequence, affected trees are certainly not in a normal condition, and the functions of the tree must be more or less interfered with, since the conductive tissues in the galls are to a greater or less extent misplaced and contorted, according to the severity of infection. There is, moreover, a risk in planting trees affected with gall, since one can never know when some complicated trouble may arise, owing to the presence of such malformed tissue.

There is a great deal known in regard to the effects of galls on plants in general, and it is known that they cause much injury.

The writer has devoted many years to the study of galls caused by eel worms (*Heterodera*). Some plants affected with eel-worm galls present few abnormal features as regards vigor and yield, while others become sickly, and many die outright.

Tomatoes grown under glass are often affected quite severely with galls caused by eel worms. These very rarely, if ever, kill the plant, and in the great majority of cases, so far as we have observed, do not affect them severely. On the other hand, cucumbers appear to be often seriously affected, and while many plants will live when the roots are covered with galls, others will die, and the yield is, in practically all cases, materially reduced. Muskmelon plants are even more severely affected with eel-worm galls than cucumbers; to such an extent, in fact, that it is seldom that an affected plant is not killed before reaching two or three feet in length. The roots of roses are also susceptible to eel worms, which form almost microscopic galls, and often reduce the productiveness of this crop 75 per cent. A considerable loss of money has been experienced by rose growers from this cause. This is also true of violets. According to our own experiments

the yield of violets is greatly affected by these galls, and the plants often die outright.

In conclusion it might be said that the effects of crown gall on fruit trees may have been often exaggerated. There is a probability of some young nursery stock affected with crown gall developing into good trees, but clean stock should be obtained from localities free from the gall, if possible. Many States have laws for the purpose of excluding crown gall stock, but this disease has become so common, and certain varieties of nursery stock so scarce, that it is a question whether at the present time Massachusetts nurserymen would be able to supply the demand for clean material for contemplated orchards if a prohibitory law were passed.

FUSARIUM DISEASE OF CUCUMBERS AND OTHER PLANTS.

BY G. E. STONE.

A type of disease caused by one or more species of *Fusarium* occurring on different plants gives rise to what are known as wilts, stem rots, etc. *Fusarium* troubles have become more common of late years, and many houses which have been entirely free from them in the past now seem to become affected sooner or later. The dry stem rot of the carnation, caused by *Fusarium*, was unknown to florists years ago, but for ten years or more it has been one of the most common and dreaded pests known to carnation growers. *Fusarium* stem troubles have been observed occasionally on greenhouse tomatoes for the past few years, but fortunately no great amount of damage has so far resulted from this disease. Asters, chrysanthemums, potatoes, etc., are affected with *Fusarium* stem rots, and in the case of the aster the disease is often quite common and destructive.

Fusarium troubles of a minor and insignificant character have in previous years been found on greenhouse cucumbers, and within the last year a few serious cases of infection have been brought to our attention. All these cases were confined to greenhouses, and were severe enough in some instances to entirely ruin the crop. The material sent in to the laboratory showed both roots and stems affected with the fungus.

The summer crop of muskmelons, grown in the department's conservatory, was also affected badly, the disease appearing first on a few plants, but eventually spreading over practically the whole house. It was first characterized by a wilting of the leaves, which was more noticeable in warm, sunshiny weather. At first there is a tendency for the leaves to recover in the night

after wilting occurs, but as the disease becomes more severe the plants wilt more badly, and after a time die. Examination of the roots and stems near the surface of the ground showed evidence of the fungus *Fusarium*. In some instances this fungus has been traced quite largely to the roots and stems. The fungus develops principally in the wood ducts, eventually clogging them by shutting off the water supply from the roots.

As the disease has been called to our attention only recently we have not had an opportunity to study it thoroughly or to give the matter of remedies much consideration. It may be found, however, that, like many others, it will prove to be merely sporadic, and little may be heard from it in the future; although on the other hand, it may become a permanent and serious trouble.

Cucumber crops are unusually susceptible to certain troubles which in many cases are traceable directly to mismanagement. Practically all cucumber growers force their plants to the limit, regardless of external weather conditions, in this respect differing from florists and other market gardeners, who endeavor to adapt their crops to weather conditions. Too much forcing in the fall months, when the sunlight is poor, produces a tender tissue peculiarly susceptible to disease, and is a bad practice. There is no doubt, in the writer's estimation, that crowding the plants and extensive forcing, especially when the sunlight is poor, are responsible for a large part of the modern *Fusarium* troubles. Some years ago we found in our experiments that young aster plants which had been forced under glass in sterilized soil were decidedly more susceptible to stem rot than those grown in ordinary soil out of doors. The sterilized plants grew so rapidly that the tissue was very tender; whereas those grown out of doors formed tissue of an entirely different texture, which was less susceptible to disease. The stems of cucumber plants are often in bad condition near the surface of the ground, due to a combination of circumstances. Mites, eel worms, bacteria, etc., often affect the stem at this point, causing lesions and serious disruption of the tissue, and stems in this condition easily become affected with one trouble or another. The *Fusarium*

trouble at present appears to be merely incidental, attacking the weakened stems at the surface of the ground; but further observations on this point are necessary.

Sunlight constitutes the best factor for hardening up tissue, and the degree of resistance of the stems to disease coincides with the amount of light they receive. Besides sunlight, plenty of air is needed for the hardening of tissue, and if more attention were given by cucumber growers to adapting their plants to external conditions, healthier and stockier plants would be produced. On cloudy days the night and day temperatures should be lower than on bright, sunshiny days, and in this way the new tissue, as well as the old, becomes hardened, and is less susceptible to attacks from various organisms.

Lettuce growers are always very careful to lower the day temperatures in cloudy weather, whereas in periods of sunshine higher temperatures are maintained. They force their plants, to be sure, but use the greatest judgment in doing it, whereas cucumber growers, as a rule, pay little or no attention to outside conditions.

Experiments are now under way for the further study of this trouble, and various treatments will be tried.

There have recently been reported from other States serious troubles affecting outdoor crops of melons and cucumbers, characterized by wilting and dying of the plants. Serious loss was reported in Rhode Island the past summer resulting from some blight. F. L. Stewart has described a serious blight of melons occurring in New York State,¹ and L. R. Jones has described a bacterial blight in Vermont.² Both of these blights are different from the one described above.

Our attention has often been called to the cracking or splitting of melons in the fall. This occurs on mature, ripe melons, and in our opinion it is caused by the absorption of water by the fruit. When melons are lying on the ground the water sometimes gains entrance to the blossom end of the fruit, causing an increased turgescence of the inner tissues which exerts such a pressure on the fruit that it cracks. We have been able to pro-

¹ Geneva, N. Y., Agricultural Experiment Station, Technical Bulletin No. 9, 1909.

² Vermont Agricultural Experiment Station, Bulletin No. 148, 1910.

duce this cracking of the fruit by placing the blossom ends in saucers of water. Sliced melons, when placed in a dish of water, will straighten out noticeably, from the excessive absorption of water by the inner cells. On the other hand, when sliced melons are placed in normal salt solutions of certain strengths the melon will contract or curl up.

CONDITION OF FRUIT TREES IN GENERAL.

BY G. E. STONE.

Any one who has been acquainted for any length of time with the fruit industry of this State must have noticed its condition the past few years. Massachusetts has never been noted as an extensive fruit-growing State, and very few large orchard enterprises have ever been developed. There have also been comparatively few orchards which have been kept in first-class condition; in fact, the condition of fruit trees has never been so bad in the history of the Commonwealth as during the past four or five years. The severe and erratic climatic conditions to which our fruit trees, in particular, have been subject, together with the San José scale, have been the means of killing thousands of our fruit trees, and greatly lessening their productiveness and the quality of the fruit. All this, combined with wholesale neglect, has placed the fruit industry at a very low level, and it is not at all surprising that apples bring at times a very low price. The severe winter of 1903-04 was not confined to our State, as its work may be seen throughout the whole north-eastern section of the United States, and in many instances large orchards were wiped out entirely.

From observations made in other States it would appear that our trees do not suffer so severely as in some other places, but the fruit has been of exceptionally poor quality. A large part of the injury to apple trees was confined to the roots, although a large amount of sun scald, which was subsequently associated with canker, was noticeable on the branches. Good systematic pruning, feeding and cultivation would have remedied much of this injury, but until the past year or so, when there has been a renewed interest in orcharding, no attempt has been made to renovate these neglected orchards. The remarkable price which

western apples bring in our markets has stimulated Massachusetts orchardists to make use of better scientific methods in fruit growing, and it is no exaggeration to state that there have been more pruning, spraying, cultivating and fertilizing apple orchards in the past year in this State than for thirty years before. This increased interest is being shown by professional orchardists as well as by smaller growers, and the quality and yield of fruit the past season is ample proof of the great value of this treatment. It is, however, a significant fact that the few first-class apple orchards which are to be seen here and there have not experienced the same setback, either from scale or winterkilling, that the neglected trees have, and some orchards have been producing good fruit each year, although the severe drought which we have experienced the last two or three years has affected trees somewhat.

Peach orchards have suffered severely of late years from root killing and other troubles, and some of the orchards which were in excellent condition a few years ago are looking badly now. Some growers attribute this deterioration to peach "yellows." A large part of what is supposed to be "yellows" is not this at all, and the yellow foliage and general unhealthy condition which have been common the past few years are nothing more or less than the effects of unfavorable climatic conditions. Pear, quince and cherry trees have likewise suffered from scale and winter injury in the same way that apple trees have. The pear, moreover, has been affected severely by aphids and surface molds. This could have been remedied by spraying with whale oil soap or kerosene emulsion. The quince has been rather badly affected by rust. Practically all the old cherry trees have suffered serious injury, and, as few new trees have been set out, cherries are becoming scarce. The small fruits, such as the raspberry, blackberry and strawberry, owe much of their present condition to unfavorable climatic conditions, and the cane blight, which has recently affected raspberries, etc., may be merely a secondary effect of some other cause.

It is, however, necessary that the work of spraying fruit trees be continued, since the results obtained fully justify the extra expense involved. The treatment necessary for fruit trees in

general may be summarized as follows: if scale is present, spray in the fall with some reliable oil. In the early spring spray again with lime and sulfur, before the leaves appear. About the time the petals fall, spray again with arsenate of lead, for codling moth. Ordinarily this spraying is sufficient, but if any fungous troubles appear, a later spraying with Bordeaux mixture, or with dilute or self-boiled lime sulfur, would be valuable. These various treatments are recommended for both fungi and insects, and although the oil, and lime and sulfur treatment are especially applicable for scale, it has been found that the latter, particularly, has proved to be the most effective fungicide we have. Even one application of lime and sulfur in the spring has a remarkable effect as a fungicide throughout the whole season, and in our opinion it is more efficient than any number of sprayings with Bordeaux mixture for certain troubles common to fruit trees. Arsenate of lead is primarily for codling moth, but this, too, has fungicidal properties, according to the writer's observations. We believe that for orchards which are well pruned, cultivated and fertilized the three sprayings recommended above would be sufficient for any ordinary year, and in case the scale is not present, the oil treatment could be left out. The lime and sulfur, however, is worth applying every year, whether the scale is present or not, owing to its remarkable fungicidal properties. There are now on the market many kinds of oils and concentrated forms of lime and sulfur which can be used to advantage. It is a question, however, whether the concentrated forms are as effective as the home-made. Much attention is now being given to the self-boiled lime and sulfur, but it is somewhat too early to state definitely its value as a fungicide.

The apple industry is now booming in this State. Many young orchards are being set out; more attention is being given to pruning, spraying and cultivating, and within a few years there will be many more good orchards than at present.

A NEW TYPE OF SPRAY NOZZLE.

BY G. E. STONE.

For some years the writer has given considerable attention to the improvement of nozzles, and has experimented with various types. In a preceding article on the spraying of trees we have already referred to the importance of nozzles being adapted to specific cases, and from time to time we have sketched and had constructed in a simple way new types of nozzles, which have been tested. The principles involved in these nozzles were in many cases new, but when the nozzles were constructed and tried out, some of them, as might be expected, were more or less failures. Various methods and devices were used and tested to break up the spray, and in one case a rotary wheel of a turbine type was tried.

Without going into a detailed description of the various types of nozzles which we have worked upon we will confine our attention to one of these which has proved to be remarkably satisfactory in spraying large trees from a high-pressure machine. This nozzle is shown in Fig. 1, at *A*. It consists of a nozzle screwed tightly onto the tip of a standard attachment provided with shut-off, such as is often employed in spraying work (see *B*). The attachment, however, is incidental, as it may be fitted to any suitable metal connection threaded to fit, and provided with a hose connection at the lower end. The essential part of the nozzle, as shown at *A*, consists of a small brass tip, *t*, about $1\frac{1}{2}$ inches long, provided with an aperture at the end $\frac{1}{8}$ of an inch in diameter, although sometimes an aperture of $\frac{5}{32}$ or $\frac{3}{16}$ of an inch in diameter has been employed. About an inch or more above the center of the aperture there is placed a solid brass rod, *c*, $\frac{1}{4}$ of an inch in diameter. This is attached to another rod, *d*, by means of a thin sheet of brass; the rod, *d*, works in a socket, and allows the pointed brass rod, *A*, to be thrown in or

out of center at will. The object of this center brass rod, *c*, is to take the spray as it comes out of the $\frac{1}{8}$ -inch nozzle under high pressure and break it up into a fine mist, and with the pressure which we used it is capable of throwing the mist 20 or 25 feet. This is sufficient to reach, from a ladder, most of the foliage on a large elm tree. In case it is necessary to reach higher, the ad-

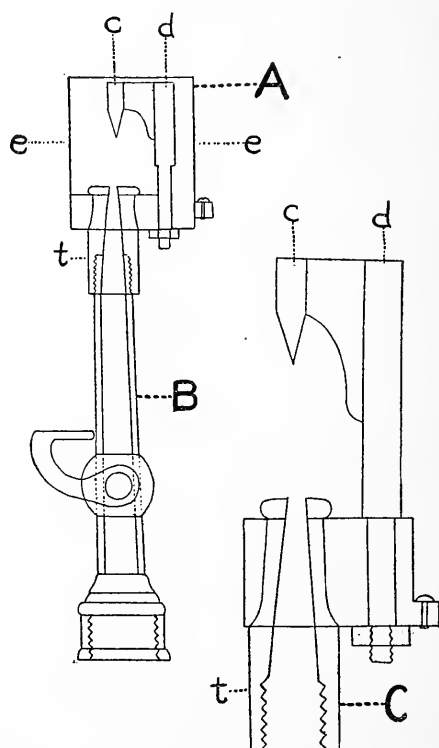


FIG. 1. — Showing a new type of spray nozzle adapted to high-pressure work on large trees. A, essential part of nozzle; B, ordinary attachment provided with shut-off; C, nozzle enlarged without a guard; *t*, small brass tip; *e*, guard; *c*, pointed brass rod to break the spray; *d*, rod to support the same.

justment is thrown out of the center and the spray goes directly through the $\frac{1}{8}$ -inch aperture. By this means a greater distance and carrying power are secured, although not so fine a spray.

This type of nozzle has proved to be very successful, and was used throughout the whole summer with the best results.

In the drawing the nozzle is shown surrounded by a shield, *e*, which was for the purpose of protecting the point, *c*. The nozzle as originally constructed was not provided with a shield, being used for some days without it, but with the hard usage which it received we found that the adjustment was likely to be injured. The nozzle was used in connection with a machine giving 250 pounds' pressure, and the spraying mixture was carried through a 1-inch hose.

This nozzle was used, the past summer, in spraying over 1,000 trees, having an average diameter of about 22 inches. Careful estimates made showed that the average amount of arsenate of lead per tree was 1.7 pounds, or about 17 gallons of arsenate of lead in solution. The cost of spraying each tree, including the labor, gasolene and lead, was 55 cents. A smaller number of the same trees were sprayed some years ago at a cost of \$1.50 per tree; but the spraying with the new nozzle and machine was in every way as good, and the cost about two-thirds less per tree, as by the more costly method, which consisted in the use of the Vermorel and other fine-mist nozzles.

DISTILLERY AND BREWERY BY-PRODUCTS.

BY J. B. LINDSEY.

A. DISTILLERS' DRIED GRAINS.

(a) *What they are.*

Distillers' dried grains represent the residue from the manufacture of alcohol, spirit and whiskey from the several cereals. Briefly stated, the process of manufacture consists in treating the ground grains with a solution of malt at a temperature of about 145° F., in order to convert the starch into sugar. The barley and other cereals from which the malt is made, as well as the malt sprouts, are added as a part of the malt solution. After the changing of the starch into sugar, the entire mass is cooled to a temperature of 60° to 70° F., and yeast added, thus changing the sugar into alcohol, which is distilled. The residue or distillery slop is filtered, dried by steam in especially constructed driers, and put upon the market as a cattle food. It consists chiefly of the hulls, germ and other nonfermentable portions of the grains. It has more or less of a sour taste and smell, due to the fermentation. In order to be of satisfactory quality, the mash should be dried at once after the process of fermentation is completed. If allowed to stand too long it is more or less contaminated with acid and other injurious products of fungous and bacterial action. If heated too hot during the drying process it is scorched, which causes a disagreeable burnt taste and odor, and a lessened digestibility. A well-dried product should be of a light brown color and possess a pleasant odor. Experienced parties state that the quality of the dried grains depends, first, upon the quality of the distillers' mashes (upon the kinds and proportions of the grains employed); second, upon the distillers' mode of mashing; and third, upon the process of drying.

(b) *Classification of Distillers' Grains.*

The grains may be classified as follows, according to the source from which they are derived: —

1. Alcohol and spirit grains are produced by the alcohol and spirit distillers, located in Indiana, Illinois and Ohio; they are the most uniform in grade, corn being practically the only grain used. The yearly product is from 50,000 to 60,000 tons.

2. Bourbon whiskey grains, from the whiskey distilleries, located mostly in Kentucky, vary in composition according to the proportion of corn, rye and malt in their mashes. The larger the proportion of corn and the smaller that of rye and malt (small grain, so called), the higher the grade of dry grains produced. The distilleries producing these grains run about one hundred and fifty days between November and July, and turn out from 27,500 to 35,000 tons.

3. Rye whiskey grains, from the rye whiskey distilleries, located near Pittsburg, Pa., and Baltimore, Md., run during the winter and spring, and may produce approximately 7,500 tons.

(c) *Disposition of Distillers' Grains.*

Formerly practically all of the dried grains were exported. About ten years ago the home market was sought, and considerable quantities were sold unmixed with other feedstuffs. Of late the better grades have been largely utilized by home manufacturers of proprietary feeds. The rye grains have never been very popular in the United States, and the entire product is usually exported. The present season (winter of 1910–11) the foreign market is said to have been poor, and the material has been freely offered at \$16 per ton in bags at wholesale, f. o. b., Boston points, which would be equivalent to substantially \$1 per hundred at retail. Such a price renders this article quite economical for northern feeders.

(d) *Composition of Distillers' Grains.*

The following summary represents the average percentages of the ordinary food groups in the several varieties of grains: —

	Number of Samples.	Water.	Ash.	Protein	Fiber.	Extract Matter.	Fat.
Distillers' grains (alcohol and spirit),	81	8	1.7	31.7	12.3	34.1	12.2
Distillers' grains (whiskey), . . .	1	7	2.5	26.2	11.5	43.0	9.8
Distillers' grains (rye),	5	7	1.6	15.6	13.5	55.4	6.9

The alcohol grains are the only ones usually found in the Massachusetts markets. They contain 30 or more per cent. of protein and about 12 per cent. each of fiber and fat. The rye grains reach 15 to 16 per cent. of protein, and contain some 13 or more per cent. of fiber. Recent analyses show that substantially all of the crude protein in distillers' grains is present as true albuminoids.

(e) *Digestibility of Distillers' Grains (Per Cent.)*

	Alcohol and Whiskey (17 Trials, 8 Lots).	Gluten Feed for Comparison.	Rye Grains (2 Trials, 1 Lot).	Wheat Bran for Comparison.
Dry matter,	79	88	58	66
Protein,	73	85	59	77
Fiber,	95	87	50	39
Extract matter,	81	90	67	71
Fat,	95	81	84	63

The alcohol or corn grains show a somewhat lower digestibility than does the gluten feed, but are much more digestible than the rye grains. If the average percentage composition is multiplied by the above digestion coefficients, we have the percentage or pounds digestible in 100:—

	Alcohol Grains.	Gluten Feed.	Rye Grains.	Wheat Bran for Comparison.
Protein,	23.1	22.0	9.20	12.4
Fiber,	11.7	6.3	6.75	3.9
Extract matter,	27.6	48.0	37.12	37.8
Fat,	11.6	2.6	5.80	2.8
Total,	74.0	78.9	58.87	56.9

On the basis of the experiments and estimates made by Kellner, allowing for losses in the (a) faeces or undigested material, (b) incompletely used material or urine, (c) work required in the processes of digestion and assimilation, the following net energy values (expressed in therms¹) are calculated in 100 pounds of the several feeds: alcohol grains, 80.2; gluten feed, 77.8; rye grains, 54.9; wheat bran, 49. It will thus be seen that the alcohol distillers' grains and gluten feed approach each other quite closely in feeding value, and likewise the rye grains and wheat bran.

A carefully conducted feeding trial with 6 cows,² in which a good quality of alcohol distillers' grains was compared with gluten feed, led to the following conclusions:—

1. The experiment has shown the distillers' grains to be fully equal, if not rather superior, to standard gluten feed in their nutritive value, and without objectionable effect on the health of the animal.

2. Their bulky nature enhances their value as a grain feed for most kinds of farm stock.

3. The flavor and keeping quality of the milk appeared in no way to be affected when this food constituted one-half of the daily grain ration.

It must be understood that grains that have undergone serious fermentation before drying cannot be considered as a first-class food, and their use is not recommended for either dairy animals or for horses.

(f) *How to use the Grains.*

For Horses.—Plumb,³ as a result of feeding distillers' grains to horses, found that some of the animals did not relish the product. The Massachusetts Agricultural College has fed its farm horses, with excellent results, a ration containing one-fourth distillers' grains; Pott⁴ reports favorably on the use of 6½ pounds distillers' grains in place of 8 pounds oats; also

¹ The therm represents the amount of heat required to raise 1,000 kilograms of water 1° C. It is to be preferred to the small or large calorie as a unit of measurement, because it can be expressed in fewer figures.

² Bulletin 94, Hatch Experiment Station, pp. 6-10.

³ Bulletin 97, Indiana Experiment Station.

⁴ Handbuch der tier. Ernährung, etc., von Pott, III Band, p. 293.

2¼ pounds distillers' grains, 2¼ pounds brewers' grains and 9 pounds corn in place of 9 pounds oats and 9 pounds corn.

For Fattening Cattle. — May¹ reports quite satisfactory results in feeding by weight one-half distillers' grains and one-half corn and cob meal to fattening cattle. It is believed that such a proportion is a desirable one, and that the distillers' grains can be thus utilized to good advantage.

For Pigs. — The distillers' dried grains are less desirable as a food for pigs, owing, partially at least, to the considerable amount of fiber present. They could probably be fed to better advantage in their natural state, *i.e.*, in the form of distillery slop.

For Dairy Animals. — The distillers' grains have been found to be exceedingly well suited to milk production. A few rations are suggested: —

I.	II.
100 pounds distillers' grains.	150 pounds distillers' grains.
100 pounds malt sprouts.	150 pounds standard middlings.
150 pounds corn meal.	100 pounds corn or hominy meal.
50 pounds cottonseed meal.	Mix and feed 7 pounds or quarts daily.
Mix and feed 7 pounds (7 to 8 quarts) daily.	

III.

150 pounds distillers' grains.
 50 pounds corn or hominy meal.
 50 pounds cottonseed meal.
 Mix and feed 7 pounds or quarts daily.

B. BREWERS' DRIED GRAINS.

(a) Character of the Grains.

Brewers' dried grains are the kiln-dried residue from beer manufacture, and consist of a little of the starch and allied substances, together with the hull, germ and gluten of the barley. Most of the true starch is removed by the action of the malt and yeast. Grains that have been dried immediately are of a yellowish green color, and have a faint aromatic smell. Dark-brown colored grains have been injured before being dried, or

¹ Bulletin 108, Kentucky Experiment Station.

have been heated at too high a temperature, thus causing decomposition. Dried grains are fed quite extensively in Europe, and to some extent in the United States. European investigators consider freshly dried grains as healthful as untreated barley, oats or corn. At present there are some 40 breweries in Massachusetts. The residue is practically all sold undried to farmers living in the immediate vicinity. The comparatively small amount of dried grains consumed in this State comes from the vicinity of New York, Chicago and Milwaukee.

(b) *Composition of the Grains (Per Cent.).*

	Brewers' Grains (Average 19 Samples).	Wheat Bran for Comparison.
Water,	10.0	10.0
Ash,	3.6	6.2
Protein,	24.0	16.1
Fiber,	13.4	10.5
Extract matter,	42.8	52.6
Fat,	6.2	5.0

In chemical composition the brewers' grains differ from the bran in having noticeably more protein, somewhat more fiber and less extract matter. Two samples of grains recently collected show 27 and 33 per cent. of protein; the latter figure is unusual, and may have been due to the use of some corn in the mash.

(c) *Comparative Digestibility.*

On the basis of the average analysis, 100 pounds of the brewers' grains and of the bran contain the following amounts of digestible nutrients:—

	Brewers' Grains (Per Cent.).	Wheat Bran (Per Cent.).
Protein,	19.4	12.4
Fiber,	6.6	3.9
Extract matter,	24.4	37.8
Fat,	5.5	2.8
Total,	55.9	56.9

Each of the two feedstuffs contains substantially the same amounts of digestible nutrients. The net energy values expressed in therms are as follows: brewers' dried grains, 56; wheat bran, 49; or the brewers' grains are worth 10 per cent. more than the bran.

An experiment conducted at this station with 6 dairy cows, in which brewers' grains were compared with wheat bran, led to the following conclusions: —

1. The brewers' grains ration produced slightly more live weight, milk and milk ingredients than did the bran ration.

2. Brewers' grains did not show any objectionable effect either on the general condition of the animal or on the flavor and keeping quality of the milk. They are nearly as bulky as bran, and serve as a distributor of the heavy concentrates.

(d) *The Use of Brewers' Grains.*

Only those grains that have a light color and are free from rancidity or sour taste and smell should be used. Grains that have stood for any length of time before drying have fermented, and are not satisfactory as a food.

For Horses. — Brewers' dried grains serve excellently as a partial oat substitute for horses, 2 pounds of the grains being equivalent to 2½ pounds of oats.¹ Voorhees² states that brewers' dried grains are a wholesome, nutritious and palatable horse feed. He recommends for work horses, on the basis of 1,000 pounds live weight, 2 pounds bran, 4 pounds corn, 8½ pounds brewers' grains and 6 pounds hay. Very satisfactory results are reported when hard-worked team horses received a daily ration of brewers' dried grains and hay.¹ The total amount of dried grains to be fed daily will naturally depend upon the size of the animal and the amount and character of the work performed. From 3 to 8 pounds may be considered satisfactory, the balance of the grain to consist of corn and oats, or corn and wheat bran.

For Pigs. — Because of their deficiency in ash and starch, and of the excess of hulls, the dried grains are not to be partic-

¹ Pott, already cited, pp. 241, 242.

² Bulletin 92, New Jersey Experiment Station.

ularly recommended either for growing or fattening pigs. When fed in connection with skim milk in place of corn, they have not produced as satisfactory a gain in live weight.

For Fattening Cattle. — The brewers' grains are quite satisfactory for fattening beef animals, in the proportion, by weight, of one-third of the grains and two-thirds of corn.

For Milk Production. — The dried grains are very satisfactory as a food for the production of milk; they may be used in place of wheat bran.

I.	II.
125 pounds brewers' grains.	150 pounds brewers' grains.
100 pounds corn or hominy meal.	75 pounds flour middlings.
75 pounds cottonseed meal.	50 pounds cottonseed meal.
Mix and feed 7 pounds or quarts daily.	Mix and feed 7 pounds or quarts daily.

III.

100 pounds brewers' grains.
 100 pounds coarse middlings.
 100 pounds gluten feed.
 Mix and feed 7 pounds (8 quarts) daily.

The above rations are for average-sized cows yielding 10 to 12 quarts of average milk daily. The amount may be increased or diminished, depending upon size of animals, yield of milk, etc.

For Young Stock. — Because of their deficiency in ash, not over 25 per cent. of the grain ration should consist of brewers' dried grains. They may be combined with bran, coarse middlings and cottonseed meal, by weight, one-fourth brewers' grains, one-half coarse middlings, one-fourth cottonseed meal; or one-fourth brewers' grains, one-fourth corn and cob meal, one-fourth coarse middlings, one-fourth cottonseed meal.

(e) *Brewers' Wet Grains.*

Brewers' wet grains contain 75 to 77 pounds of water in 100, and are practically all sold to farmers living in the immediate vicinity of the brewery, at prices ranging from 10 to 12 cents a bushel. Assuming that 33 bushels weigh a ton, the cost would

be from \$3.30 to \$4 at the brewery, to which the cost of cartage should be added. Four tons of wet grains contain nutritive material equivalent to that found in 1 ton of dry grains, or in 1.1 tons wheat bran, or in $\frac{3}{4}$ ton gluten feed. With these data at hand, the purchaser of this material can calculate at what price he can secure an equal amount of nutrients in the various dry feedstuffs. The writer has not had any experience in feeding wet grains, but believes that 25 pounds is a fair allowance daily for average-sized cows.¹ In addition, 2 to 4 pounds of dry grain may be fed daily, such as a mixture of equal parts by weight of (1) mixed wheat feed and gluten feed, (2) wheat bran and fine middlings, or (3) wheat bran and corn meal.

The succulency of the wet grains is a factor not to be overlooked in estimating the value of the feed. It is not believed that the brewers' wet grains are an objectionable feedstuff when fed in a fresh condition and in moderate quantities. It must be remembered, however, that they are likely to spoil easily, excepting when the temperature is low, and the partly decomposed grains would not be considered suitable for producing first-class milk. When milk is intended for the use of infants, young children or invalids, it is better not to use the wet grains.

C. MALT SPROUTS.

(a) *Method of Preparation.*

Malt used in the manufacture of beer is prepared by moistening barley and allowing it to sprout in a warm atmosphere, thus producing a ferment called diastase, which readily converts starch into sugar. After the sprouting process has continued a number of days, the barley is dried, the sprouts removed by machinery and sold for cattle feed; each 100 pounds of malted barley yields about 4 pounds of sprouts. Sprouts of first quality are about $\frac{1}{4}$ of an inch long, thread-like in appearance, slightly curled, of a yellow or of a brownish yellow color, and form a crisp, porous and bulky mass. Mixed with the sprouts one often notes more or less malted barley kernels,

¹ It is understood that 50 or more pounds are frequently fed daily. It is believed, however, that the smaller quantity is preferable when the grains are fed continuously, and it is desired to retain the same animals in the herd from year to year.

dust and ash. The presence of the dust and ash is due to the fact that some of the sprouts are particularly rich in ashy matter, and because this ashy matter and dust have not been fully removed. Well-cleaned sprouts should be given the preference.

(b) *Composition (Per Cent.).*

	Average 32 Samples.	Average German Sprouts. ¹
Water,	11.0	10.0
Ash,	5.9	7.2
Protein,	26.4	24.4
Fiber,	12.3	14.0
Extract matter,	43.1	42.4
Fat,	1.3	2.0
Total,	100.0	100.0

The sprouts are characterized by a high percentage of crude protein, considerable fiber and little fat. While the nitrogenous matter in the sprouts is usually designated as true protein, it is well known that from one-fourth to one-third of the nitrogen exists in the form of amids,² hence the sprouts contain about 18 per cent. of true protein. Amid bodies are sources of heat and energy, and seem to protect the rapid breaking up of the true protein in the animal body, but they cannot produce flesh or milk casein. The extract matter contains a large amount of cane sugar, a little invert sugar and a considerable amount of pentosans. The fiber content is often increased by the presence of barley hulls. The ash is rich in potash and phosphoric acid and deficient in lime.

¹ E. Pott, already cited, p. 222.

² In the process of growth the plant elaborates the nitrates of the soil, first, into amid compounds, — partially developed protein, — and finally into the completed product, or true protein which is largely deposited in the seed. When the seed begins to sprout the true protein is converted back into the soluble amids, to enable the young sprouts to utilize it. Amids may be defined, so far as their use in the plant is concerned, as transportable protein.

(c) *Digestibility.*

One hundred pounds contain:—

	Pounds.
Protein,	20.1
Fiber,	12.2
Extract matter,	36.6
Fat,	1.1
Total,	70.0

The sprouts have a relatively high digestibility and a net energy value of 56.4, just about equivalent to that for brewers' dried grains.

(d) *The Use of Malt Sprouts.*

Malt sprouts are at present used in considerable quantities as a component of many proprietary dairy feeds. They are particularly suited for dairy animals and for fattening cattle.

For Dairy Cows.—This station compared malt sprouts with gluten feed, using four animals in two three-week periods. The malt-sprout ration gave as satisfactory results as did the gluten-feed ration. Foreign investigators state that they are valued for milk production because of the stimulating effect of the amido bodies (and perhaps, also, of the betain and cholin which they contain) upon the mammary glands. If over 2 pounds daily are fed, it is advisable to mix them with water, otherwise digestive disturbances may result. Fed in dry condition in any considerable amount they are likely to be refused by many animals.

I.	II.
100 pounds malt sprouts.	100 pounds malt sprouts.
100 pounds corn meal.	125 pounds rye feed.
100 pounds cottonseed meal.	75 pounds cottonseed meal.
Mix and feed 7 pounds (7 to 8 quarts) daily.	Mix and feed 7 pounds (7 to 8 quarts) daily.
III.	IV.
3 pounds (5 quarts) malt sprouts.	3 pounds (5 quarts) malt sprouts.
2 pounds (3½ quarts) brewers' grains.	2 pounds (2 quarts) hominy meal.
2 pounds (1½ quarts) fine middlings.	2 pounds (1½ quarts) cottonseed meal.

In case of rations III. and IV., it would be advisable to thoroughly moisten the sprouts and then mix the other two grains with them. If the sprouts are not fed in excess of 2 pounds daily, they can replace wheat bran pound for pound in any grain ration. An excess of sprouts is to be avoided because they are deficient in lime, and also because they are likely to cause abortion and possible failure to breed. Pott states that over 3.5 pounds daily are likely to impart an aromatic bitter taste to the milk, sometimes diminishing and sometimes increasing its fat content.

For Fattening Oxen. — Some 2 to 4 pounds daily of malt sprouts (moistened) mixed with corn meal can be utilized with good results for fattening cows or steers.

For Young Calves. — According to F. Lehmann,¹ after the animals are three months old, malt sprouts, thoroughly moistened with boiling water, can be fed lukewarm, beginning with small amounts and gradually increasing to 1 to 2 pounds per day. A few pounds per day can also be fed to growing stock, mixed with middlings and corn meal if the animals receive a good quality of hay.

For Horses. — German feeders frequently, with satisfactory results, feed to horses 2 to 5 pounds daily of malt sprouts moistened with water, in place of a like amount of oats. The sprouts should be fed in small amounts at first (1 pound daily), until the animals become accustomed to them.

¹ Pott, already cited, p. 226.

THE FEEDING VALUE OF APPLE POMACE.

BY J. B. LINDSEY.

There is often considerable discussion in the agricultural press and among farmers concerning the value of apple pomace as a food for dairy and beef cattle. With a view to getting a few positive data, this station instituted a number of experiments, the results of which are here briefly stated.

(a) *Composition of Apple Pomace (Per Cent.).*

	Water.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sample I.,	81.40	.73	.94	3.00	13.03	.90
Sample II.,	80.20	.60	1.01	3.19	13.73	1.27
Corn silage for comparison, .	80.00	1.10	1.70	5.40	11.10	.70

It will be seen from the above figures that apple pomace is a carbohydrate feed similar to corn silage. It contains about the same amount of water, rather less protein and fiber, and a larger proportion of extract matter. Whether the extract matter in the pomace is as valuable, pound for pound, as that contained in the corn, has not been thoroughly demonstrated.

(b) *Digestibility of Apple Pomace.*

The value of a feed cannot always be measured by its composition. A food is valuable as a source of nutrition only in so far as its various constituents can be digested and assimilated. This station has made two different experiments to ascertain the digestibility of the pomace, and the detailed results are to be found in the seventeenth report of this station. The summary follows:—

Summary of Experiments (Per Cent.).

	Number of Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Apple pomace (first experiment).	3	72.5	54.7	—	61.6	84.5	47.2
Apple pomace (second experiment).	3	70.6	42.8	—	67.3	84.3	43.4
Average,	6	71.5	48.7	—	64.4	84.4	45.3
Dent corn silage (for comparison).	17	64.0	—	52.0	62.0	69.0	85.0
Flint corn silage (small varieties).	11	75.0	—	65.0	77.0	79.0	82.0

The results show the total dry matter in apple pomace to be about as digestible as in the best grades of silage. The protein content of the pomace is small, — about 1 per cent., — and it has not been possible, by present methods, to ascertain its digestibility. Judging from the composition and digestibility of the pomace, one would feel justified in assuming that, pound for pound, it should approach in feeding value an average quality of corn silage.

(c) Experiments with Dairy Animals.

While this station has not carried out any exhaustive comparative tests with pomace and other coarse feeds, it has fed the pomace a number of seasons to dairy animals. The material was drawn fresh from the mill, and placed in a large pile under cover. A noticeable quantity of juice gradually drained from it, but it kept in good condition for two months. The animals received from 15 to 30 pounds daily, ate it readily, and the results were quite satisfactory. In one case 2 cows were fed alternately, four weeks at a time, on grain and hay, and on grain, hay and pomace; 25 pounds of pomace were compared with 5 pounds of hay. During the pomace period the animals produced 1,153 pounds of milk, and gained 24 pounds in live weight; during the hay period, 1,138 pounds of milk, and lost 6 pounds in weight. On this basis 5 pounds of pomace were more than equivalent to 1 pound of hay. Judging from this feeding test, and from the composition and digestibility of the

pomace, it seems probable that 4 pounds, when fed in what is termed a "balanced ration," would be equal in feeding value to 1 pound of good cow hay.

The Vermont Experiment Station has fed apple pomace for four years, using in all 20 cows in the several trials. The pomace was shoveled into the silo, leveled off, and kept in good condition without further care. In some cases it was placed on top of the corn silage after the latter had settled. The quantity fed varied from 10 to 35 pounds daily, with no unfavorable effects. As a result of the several experiments, the Vermont station concludes that the pomace is equivalent in feeding value to an equal weight of average corn silage,¹ and that it is without injurious effect on the flavor of milk and butter.

Farmers are cautioned not to feed too large quantities at first, but to begin with 10 pounds daily, and to gradually increase the quantity to 30 pounds, taking a week or more in which to do it. In this way, danger of a sudden milk shrinkage or of the animals getting "off feed," as is sometimes reported, may be avoided. Judging from all the data available, it is believed that farmers living in the vicinity of cider mills will find it good economy to utilize the pomace as a food for their dairy stock.

¹ There is doubt in the mind of the writer whether pomace would prove equal to well-preserved and well-eared corn silage; it certainly would approach it in feeding value, and ought to be fully utilized.

THE EFFECT OF PROTEIN UPON THE PRODUCTION AND COMPOSITION OF MILK.

BY J. B. LINDSEY.

Investigations and observations indicate that milk is not a simple fluid secreted directly by the blood, but a complex substance resulting from the activity of the milk cells. The cells and milk glands take from the blood and lymph vessels materials suited to their purpose, and by chemical and physiological processes convert them into a different substance, namely, milk. Milk, therefore, consists for the most part of reconstructed cell substance, and it is not possible, by any system of feeding, to produce very great modification in its composition. The composition of milk depends principally upon the breed and individuality of the cow, stage of lactation, and development of the milk cells.

German investigators, during the years 1868 to 1876, studied the additions to the different basal rations of increasing amounts of protein upon the composition of the milk, and noted only very slight variations. Danish observers, as a result of experiments by the group method with 1,152 cows, concluded that the protein was practically without influence in varying the proportions of the several milk ingredients. American experimenters report similar conclusions.

This station, from time to time, has conducted a number of experiments to observe the influence of different amounts of protein in increasing the quantity of milk, to note the protein requirements of dairy animals, and also to study its influence in modifying the proportions of the several milk ingredients. Some of these results have been published in reports of the station, and they have been recently summarized in detail in Part I. of this report. The following are the principal conclusions: —

1. By protein minimum is meant the amount of digestible protein required to support the daily life of an animal of 1,000 pounds live weight, and amounts to about .7 of a pound of crude protein daily; it also includes the amount contained in the milk, which is about .035 of a pound for each pound of milk, or .7 of a pound for 20 pounds of milk. Hence the protein daily minimum for a 1,000-pound cow producing 20 pounds of milk would be substantially 1.4 pounds of digestible protein.

2. A large excess of digestible protein (1.5 pounds, or 100 per cent.) above the protein minimum increased the flow of milk some 15 per cent. in experiments extending over periods of four weeks.

3. No particular difference was noted in the milk yield in case of two herds of cows receiving the same amount of total digestible matter, one receiving 65 per cent. and the other 122 per cent. of digestible protein above the protein minimum. Such a result indicates, at least, that the former excess was sufficient.

4. A 50 per cent. excess of digestible protein daily above the protein minimum in an experiment by the reversal method, extending over a period of nine weeks, produced some 5.9 per cent. more milk than did a ration with 21 per cent. excess protein.

5. Under similar conditions an excess, above the minimum, of 65 per cent. digestible protein produced 7.4 per cent. more milk than did an excess of 39 per cent. (Experiment covered twenty-six days.)

6. In Experiment VI., extending over a period of eleven weeks, with 12 cows by the group method, an excess of .54 of a pound of protein, 31.3 per cent. over the protein minimum, produced an apparent increase of 10 per cent. in the milk yield.

7. In Experiment VIII., extending over periods of twenty-four to thirty weeks, with 10 cows by the group method, the cows receiving the protein minimum did not shrink any more than those receiving each .44 of a pound daily, or 28 per cent., protein above the minimum.

The group method of experimentation is best suited for conducting experiments where a relatively large number of

animals — 20 or more — is available. With a less number the influence of individuality is altogether too pronounced.

8. An excess of 30 per cent. of digestible crude protein above the protein minimum (equal to 1.80 pounds of protein per day) will be productive of satisfactory results in case of cows weighing 900 pounds and producing daily 12 quarts of 4 per cent. milk.¹

An excess of 50 per cent. of digestible crude protein above the protein minimum is believed to be ample for all ordinary requirements.

9. Protein in excess of the above-suggested amounts may temporarily increase the milk yield, but it seems probable that in many cases the influence of individuality is likely to be more pronounced than the effect of the protein consumed.

10. Under the usual conditions, varying amounts of protein appear to be without influence upon the composition of the milk.

¹ Armsby, in Farmers' Bulletin No. 346, United States Department of Agriculture, expresses substantially the same idea in allowing .05 of a pound of digestible true protein for each pound of average milk, in addition to the maintenance requirement of .5 of a pound of digestible true protein per 1,000 pounds live weight. It is possible that animals can even do very good work with .04 of a pound of protein for each pound of milk.



INDEX.

INDEX.

	PAGE
Alfalfa, conditions essential to success with the crop,	25
Date of sowing,	29
Diseases of,	31
Fertilizer requirements of,	26
Harvesting,	32
In Massachusetts,	24
Inoculation of,	30
Kind of seed needed,	30
Lay of the land (topography) for,	25
Method of applying fertilizers in preparation for,	28
Necessity of lime for,	26
Number of crops and yield per year,	24
Nurse crops for spring sowing,	29
Preparation for summer sowing,	29
Preparation of the soil for,	28
Quantity of seed needed,	30
Season for sowing,	27
Secondary value of,	33
Seeding to,	27
Soils best suited for,	25
Top-dressing,	33
Apple pomace, composition of,	84
Feeding experiments with dairy animals,	85
Feeding value of,	84
Brewers' dried grains, character of,	76
Comparative digestibility of,	77
Composition of,	77
Use of,	78
Use of, for fattening cattle,	79
Use of, for horses,	78
Use of, for milk production,	79
Use of, for pigs,	78
Use of, for young stock,	79
Brewers' wet grains,	79
By-products, distillery and brewery,	72
Chestnut disease (<i>Diaporthe parasitica</i>),	56

	PAGE
Clogging drain tile, experiments bearing on,	36, 39
Clogging of drain tile by roots,	43
Conclusions, leading, summary of,	7
Crown gall of fruit trees,	58
Cucumbers and other plants, fusarium disease of,	62
Dairy animals, feeding experiments with apple pomace for,	85
Diseases of alfalfa,	31
Distillery and brewery by-products,	72
Distillers' dried grains, classification of,	73
Composition of,	73
Digestibility of,	74
Disposition of,	73
How to use for fattening cattle,	76
How to use for dairy animals,	76
How to use for fattening pigs,	76
How to use for horses,	75
What they are,	72
Drain tile, clogging, by roots of pear tree,	44
Chemically treated fibers for preventing,	36, 38, 39
Creosote fiber effective in preventing,	41
By roots,	35
Danger of clogging by roots,	43
Feeding value of apple pomace,	84
Fertilizer requirements of alfalfa,	26
Fertilizers, methods of applying in preparation for alfalfa,	28
Fruit trees, crown gall of,	58
General condition of,	66
Fusarium disease of cucumbers and other plants,	62
Harvesting alfalfa,	32
Inoculation for alfalfa,	30
Lime, necessity of, for alfalfa,	26
Malt sprouts, composition of,	81
Digestibility of,	82
Method of preparation,	80
Summary of feeding experiments with,	85
Use of,	82
Use of, for dairy cows,	82
Use of, for fattening oxen,	83
Use of, for horses,	83
Use of, for young calves,	83
Materials used in top-dressing pastures,	21
Milk, production and composition of, effect of protein on,	87
Mowings, permanent, top-dressing, general plan of,	11
Mowings, permanent, top-dressing of,	10
New type of spray nozzle,	59

	PAGE
Pastures, top-dressing,	18
Conditions under which likely to be profitable,	20
Materials (chemicals) used in,	21
Season for,	23
Permanent mowings, method of applying fertilizers in top-dressing for, .	17
Muriate of potash and slag meal both with and without nitrate of soda for,	12
Nitrate of soda with slag meal and high-grade sulfate of potash for, .	13
Nitrate of soda with slag meal and low-grade sulfate of potash for, .	13
Nitrate of soda with slag meal and muriate of potash for,	12
Results of top-dressing, summary of general observations on,	14
Slag meal, and high-grade sulfate of potash both with and without nitrate of soda for,	13
Slag meal and low-grade sulfate of potash both with and without nitrate of soda for,	13
Slag meal and muriate of potash both with and without nitrate of soda for,	12
Sulfate of potash, high-grade, and slag meal both with and without ni- trate of soda for,	13
Sulfate of potash, low-grade, and slag meal both with and without ni- trate of soda for,	13
Protein, effect of, upon the production and composition of milk,	87
Roots, clogging of drain tile by,	35
Shade tree troubles,	52
Spraying of trees,	47
Spray nozzle, new type of,	59
Summary of leading conclusions,	7
Top-dressing alfalfa,	33
Pastures,	18
Permanent mowings,	10
Trees, spraying of,	47



